

**SEA LAMPREY SPAWNING:
MICHIGAN STREAMS
OF LAKE SUPERIOR**

SPECIAL SCIENTIFIC REPORT: FISHERIES No. 70

**UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE**

Explanatory Note

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Washington, D. C.
February, 1952

United States Department of the Interior, Oscar L. Chapman, Secretary
Fish and Wildlife Service, Albert M. Day, Director

SEA LAMPREY SPAWNING: MICHIGAN
STREAMS OF LAKE SUPERIOR

by

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Introduction

During the three decades since the capture of the first specimen in Lake Erie in 1921, the sea lamprey (Petromyzon marinus) has established itself in great numbers in the upper Great Lakes. Partial destruction of the commercial and sport fisheries of Lakes Huron and Michigan has resulted. Details of the problem in those lakes have been presented in recent papers (Applegate 1950; Hile 1949; Hile et al. 1951).

The present situation in Lake Superior differs from that in Lakes Huron and Michigan in that the sea lamprey is still in its initial states of dispersal and establishment (first specimen taken at Isle Royale, 1946). The lamprey appears already to have caused some damage to the fish populations (especially lake trout) in the Superior basin. Commercial catches have declined (owing partially, perhaps, to increased fishing pressure) throughout the lake, but the greatest decrease has taken place in the eastern areas. If the relation between the fish populations and the sea lamprey follows the pattern established in Lakes Huron and Michigan, commercial fishing for lake trout and certain other species of present importance in Lake Superior will be unprofitable within three or four years.

Control of the sea lamprey in all of the lakes will probably be effected by attacking the parasite during one of the stream phases of its life cycle; for example, the upstream migrations of sexually mature individuals can be blocked by dams, mechanical weirs, and electrical barriers in streams suitable for spawning (Applegate and Smith 1951).

The relative importance of most of the watersheds of the Lake Huron and Lake Michigan basins as sea-lamprey spawning areas has been determined. Suitable spawning habitat is present in only a small percentage of streams in these basins. Unfortunately, those streams that do possess this facility have a tremendous potential for reproducing the species.

Before the stream surveys reported herein, little was known of the characteristics of the majority of the streams flowing into Lake Superior or of their relative importance as present or future producers of sea lampreys.

The surveys of Lake Superior streams were instituted to determine the following:

1. The extent of sea lamprey penetration westerly in Lake Superior, as judged by actual observations of lampreys, spawning activities, and nests in the tributary streams (sea lampreys are now distributed throughout the lake).

2. The location and extent of potential spawning and larval habitats in the streams of the basin. Criteria used to determine the relative suitability of streams were established by Applegate (1950) and other workers; specific water temperatures, velocities, and bottom types necessary for successful completion of the stream phases of the life cycle were determined.

3. The best sites for control structures in streams which are apparently suitable or are actually used by sea lampreys for spawning.

During the summer of 1950, all of the streams from the Tahquamenon River (Chippewa County, Mich.) west to the tip of the Keweenaw Peninsula were examined (figs. 1-17). The personnel included, in addition to authors, Clifford Brynildson, Daniel Garn, William Gaylord, Carl Jacoby, Alberton McLain, and Phillip Parker. The 1951 survey was conducted by Howard Loeb, William Gaylord, Carl Jacoby, and George Simmons; this party examined streams in the area between the tip of the Keweenaw Peninsula and the Michigan-Wisconsin border (figs. 1, 18-23).

Appreciation is extended to the Institute for Fisheries Research, Michigan Department of Conservation, for data on the Two Hearted River, and to Leo F. Erkkila of the Fish and Wildlife Service for data on utilization by the lamprey of several streams (table 23). Alan C. Bennett prepared the maps, and William Gaylord identified lamprey larvae.

Digest of principal findings

Results of the 1950 and 1951 stream surveys in the Lake Superior watershed are summarized as follows (figs. 2-17 and 18-23):

Number of streams and tributaries examined:

1950: 869 (Tahquamenon River west to the tip of Keweenaw Peninsula)

1951: 178 (tip of Keweenaw Peninsula west to Michigan-Wisconsin border)

Of the streams examined in 1950, detailed data were obtained for 330. (Tables 1-16 present information on the 112 streams which possessed some potential for reproducing the sea lamprey.) The remaining 539 streams which appear on large-scale maps of the area were found to fall in one of the following categories:

1. Nonexistent.
2. Considered from preliminary examination as not suitable for the reproduction of sea lampreys.
3. Tributaries not in need of examination because extensive potential spawning habitat had already been found in the watershed.

Detailed data were collected for all of the 178 streams examined in 1951 (tables 17-22). The 1951 survey was less extensive than that of 1950 in that most of the minor tributaries of each watershed were not examined.

However, all of the 315 watersheds flowing directly into Lake Superior from the Tahquamenon west of the Michigan-Wisconsin border (1950 and 1951 survey areas) have now been examined in sufficient detail for the purposes of this survey.

Streams with a large productive potential (Space for more than 75 nests): 53

Streams with a medium productive potential (Space for 6 to 75 nests): 117

Streams with a small productive potential (Space for 1 to 5 nests): 75

The standards on which the above groupings are based are, of course, arbitrary and are intended only to provide a convenient system of classification. Productive potential is defined as the capacity of a stream to produce sea lampreys, expressed as the number of nests which may be constructed on the spawning sites available when:

1. Certain less variable factors such as quality of gravel (Spawning material), gradients, velocities, and stream sizes are believed to be satisfactory for reproduction.
2. Highly variable factors such as temperature and effects of freshets, which cannot be accurately evaluated (in most situations) on the basis of available information, are considered as favorable.
3. Survival of larvae from the nests may be anticipated to be normal.

Streams in which adult sea lampreys were observed or reported (see also table 23):

1950 survey area: 7 (Additional records available from 1951 rechecks will be presented in a later report.)

1951 survey area: none (Most of the streams were examined after the spawning season.)

Streams in which sea lamprey nests were observed or reported (see also table 23):

1950 survey area: 14 (Additional records available from rechecks made in 1951 will be presented in a later report).

1951 survey area: 1

It is probable that nests were present in other streams but were not observed because:

1. The general rarity of nests in the Lake Superior region would make it entirely possible to miss an occasional single nest.
2. The brown color of many streams may have obscured some nests.
3. Nests may have been destroyed in streams examined long after the spawning season.

Streams in which sea-lamprey larvae were obtained (see also table 23):

1950 survey area: 1 (Almost all streams were examined for larvae; lamprey larvae of several species were obtained from 23 streams).

1951 survey area: none (No streams in this area were checked for larvae).

Streams upon which some type of control may eventually be necessary:

1950 survey area: 112

1951 survey area: 136

Tributary streams in this group can be controlled by devices placed on main streams. The need for control on many of these streams can be determined only by future examination.

Stream mileages: Over 1,300 miles of stream were surveyed in 1950; the combined lengths of all streams in the area amount to considerably more than that. The lengths of all streams in the 1951 area aggregate over 1,500 miles, of which several hundred miles were surveyed.

Standards and methods

Criteria used in estimating the productive potentials of Lake Superior basin streams were established during a study of the life history of the sea lamprey by Applegate (1950).

The life history of the sea lamprey in the Great Lakes can be summarized as follows. In the spring the adults ascent streams and spawn on gravel. After a short period of incubation the eggs hatch and the larvae emerge. These larvae, carried downstream by the current, dive for and burrow into the bottom when quiet water is reached. Metamorphosis takes place after a larval life of about 4 years. The resulting sexually immature adults are carried by high water to the lakes where the parasitic life of 12 to 20 months begins.

For successful completion of the stream phases of the life cycle, certain known basic conditions among others must prevail in the streams. Suitable larval habitat consisting of soft (sand or silt) bottom material must be present in the streams proper or in their estuaries. In order to spawn, adult lampreys require (1) water temperatures of about 53° F. or above, (2) water velocities of 1 to 5 feet a second, and (3) the presence of suitable gravel formations (or other hard elements such as clam shells) for nest building (Applegate 1950). These factors were found to be of optimum quality in certain streams when (1) water temperatures were between 60° F. and 70° F.; (2) water velocities ranged from 1 to 3 feet a second; (3) stream-bed formations consisted of concentrated gravel of ideal size (3/4 inch to 3 inches in diameter) in bars or ridges which formed riffle areas. These criteria are based on studies of lampreys in streams flowing into Lakes Huron and Michigan. It is suspected that spawning may be inhibited in many Lake Superior streams by certain conditions which are common in that area, such as colder water temperatures, steep gradients, sudden freshets, and heavy turbidity due to lake clay.

The streams were examined by walking or canoeing along their courses for the distance required to determine their productive potentials; if abundant spawning habitat or an obvious barrier was found in a stream section just above the mouth, examination of that stream was discontinued; streams in which gravel was lacking were surveyed from mouths to headwaters to make certain of the lack.

Standardized methods and techniques were employed so far as it was practical to do so. The necessity for covering a large amount of territory demanded deviation from preferred methods (usually the employment of visual estimates instead of measurements) often enough to warrant an explanation of those actually used in this particular survey.

Stream lengths: Computed from county maps (Michigan Department of Conservation); a correction factor (variable) based on the estimated increase due to meandering, was applied to each computed length.

Stream widths: Average widths were computed from a series of measurements and visual estimates taken at varying distances apart; accurate measurements (steel tape) were made at potential control sites, and at most points where lampreys, nests, and suitable spawning habitat were located. At the beginning of the 1950 survey, the majority of widths were determined by direct measurement. As the season progressed and biologists became more experienced, most widths were determined by visual estimates checked frequently by tape measurements.

Stream depths: Depths were determined at the time widths were recorded. Accurate depth measurements in shallow streams were made with a yardstick. The average depth of a stream at any one point was calculated from measurements at the stream center and at points midway between the center and the edges. Individual depths in deep streams (often turbid) were obtained with a sounding line.

Water velocities: Velocities were determined at the time widths and depths were recorded. At the beginning of the survey, velocities at individual points were taken by the "chip" method (velocity in feet per second was calculated from the time required for a small glass vial half filled with water to float over a measured distance; an average was obtained from three measurements). As the survey progressed, velocities were determined by visual estimates, checked frequently by the chip method. The chip method was impracticable in many small streams because of obstructions.

Water temperatures: Taken with Taylor pocket thermometers to the nearest degree Fahrenheit.

Gradients: Determined by visual estimation, and classified as follows:

Slight: Stream bed appearing to be flat or with slight evidence of gradient.

Steep: Appearing to be approximately 1° or more.

Moderate: Between slight and steep.

Visual estimates were accurate enough for the purposes of this survey. Gradients were noted frequently.

Bottom types: The total amounts of each type were arrived at by visual estimates. Soft bottom was classified as sand, silt, mud, and clay. The presence of hardpan was also noted. Hard bottom was classified as bed-rock, boulders (12 inches in diameter and up), rubble (3 inches to 12 inches in diameter), large gravel (3/4 inch to 3 inches in diameter), and small gravel (1/4 inch to 3/4 inch in diameter).

Spawning sites: Gravel deposits were classified as follows (in order of suitability):

1. Concentrated

- a. Gravel bars and ridges on riffles.
- b. Continuously flat, pavement-like formations in riffle areas.

2. Scattered

- a. Patches of large gravel.
- b. Discontinuous, variable amounts of gravel in or upon other substrata.
- c. Gravel mixed with rubble and boulders.

Possible number of nests: A visual estimate was made of the possible number of nests which could be constructed on the gravel formations present.

Barriers: Classified as natural or man-made. Great Lakes sea lampreys cannot ascent smooth perpendicular barriers which are 3 feet or more in height. Their ability to ascend broken and irregular rock formations is greater; they have been observed negotiating a falls 7 feet high, which had a face of irregularly eroded limestone.

Adult lampreys and nests: Locations and numbers of nests were recorded with accompanying notes on type of spawning material, quality of gravel formations, and other factors. The numbers of adult lampreys were recorded in relation to activity (swimming, resting, spawning), condition (unspawned, partially spawned, spent, dying, or dead), and location. Samples of lampreys were collected and preserved.

Larval lampreys: During the 1950 survey, almost all streams were examined at various distances below spawning habitat for larvae, which were collected from all types of habitat by digging. All larvae were preserved for identification. No attempt was made to collect larvae in 1951.

Color of streams: Classified as brown or colorless, by visual examination.

Turbidity of streams: Classified as clear, or slightly, moderately, or heavily turbid.

Water levels: Annual fluctuations were determined by noting high-water marks and condition of stream at time of examination. When possible, the characteristics of individual streams in relation to extent of precipitation were recorded. Special attention was paid to water-level conditions at proposed control sites.

Pollution: Sources of industrial and domestic pollution were noted (visually) and recorded.

General topography and geographical features: Stream banks, flood plains, and the surrounding country were described. General measurements such as heights, widths and contour were recorded. Soil and plant types were noted, although not in great detail. Road conditions, location of power lines, and relative accessibility of streams and proposed control sites were noted.

Location of control sites: Potential control sites were located in most streams which were found to have productive possibilities. Criteria for selecting control sites (for mechanical weirs; barrier dams, and electrical devices) were established during experimentation with various types of control devices (Applegate and Smith 1951). Flora and fauna: Only limited observations were made. Exceptional conditions (for example, extreme abundance of aquatic plants) were noted. A limited amount of seining for fish was done.

Evaluation of streams

For the sake of convenience and simplicity, the entire Michigan watershed of Lake Superior has been divided into 22 areas (figs. 2-23; tables 1-22), each of which is discussed separately.

With each figure and table are brief comments on the area and its streams, factors which may inhibit or prevent spawning in the future, and control possibilities.

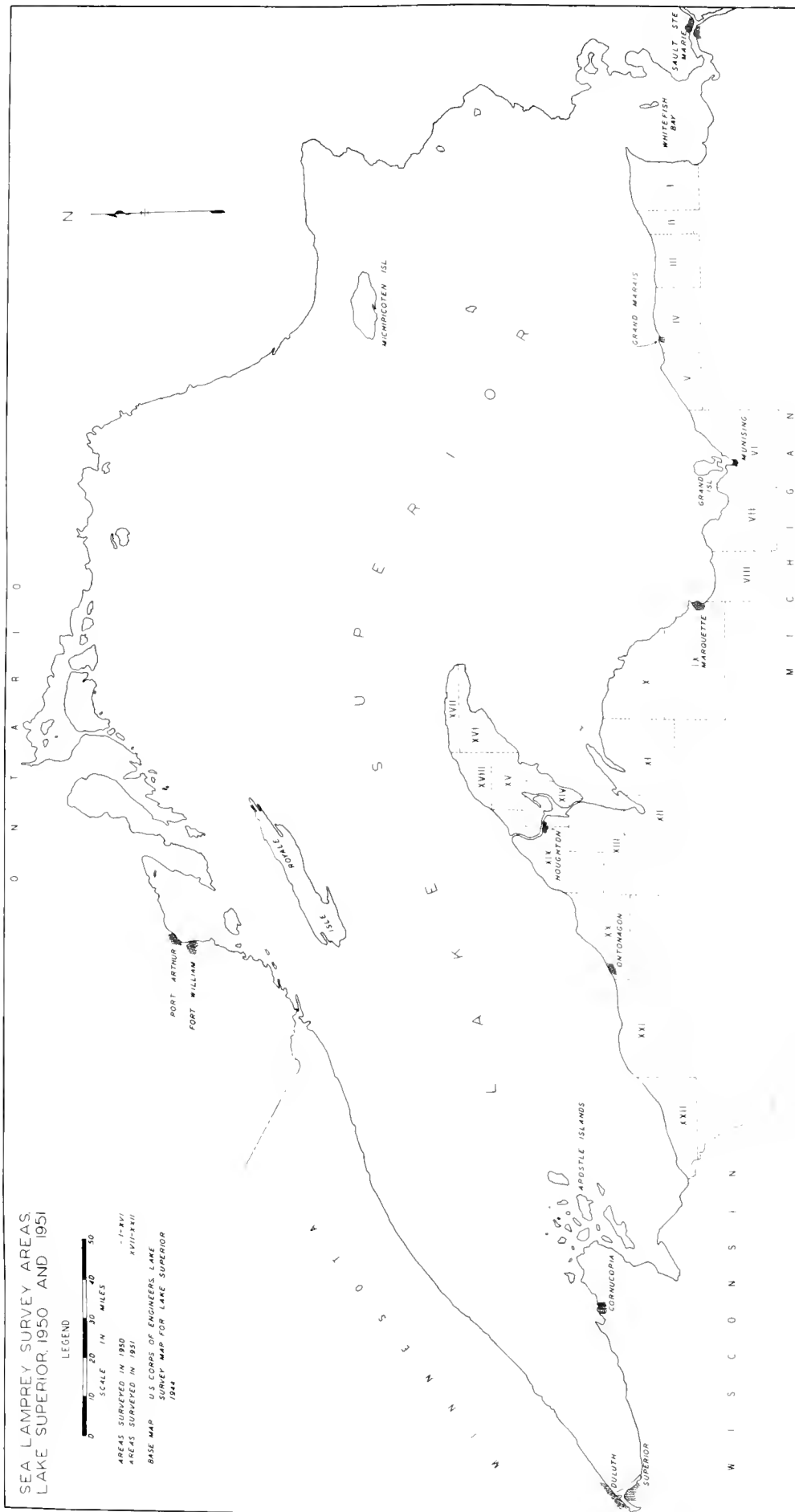


Figure 1.—Lake Superior, showing areas, and their arbitrary subdivisions, surveyed in 1950 and 1951.

Table 1.--Productive potential, recommended control devices,
and miscellaneous factors concerning streams in Area 1
(Survey made in 1950)

| Name of stream ^{1/} | County, township line, range, and section no. at mouth | Length of stream in miles ^{2/} | Average width of stream ^{3/} in ft. | Average depth of stream ^{3/} in ft. | Range in gradient ^{3/} in ft./sec. | Range in velocity in ft./sec. ^{3/} | Tempera- tures in degrees F. ^{3/} | Date | Productive potential | Possible limiting factors | Type of control possible ^{4/} |
|------------------------------|--|---|--|--|---|---|--|-----------|-------------------------|--|--|
| Tahquamenon River | Chippewa, 48-6-14 | 20.0 | 300.0 | 8.0 | Slight-moderate | Sluggish-5.0 | 58-68 | 6/6-6/29 | Medium | Spawning sites, velocity Temperature | Electrical |
| Obriens Creek | Chippewa, 49-6-27 | 2.0 | 4.0 | 1.5 | Slight-moderate | Sluggish-2.5 | 52-68 | 6/9-7/10 | Small | None | Mechanical weir & trap |
| Betsy River | Chippewa, 49-6-2 | 42.0 | 25.0 | 2.0 | Slight | Sluggish-3.0 | 55-71 | 6/13-7/10 | Large | None | Electrical |
| Creek # 1 | Chippewa, 50-7-1 | 0.25 | 8.0 | 0.5 | Slight | 1.25 | 63 | 6/28 | Small | Shifting bottom | Mechanical weir & trap |
| Vermilion Creek | Chippewa, 50-7-2 | 0.25 | 10.0 | 1.0 | Slight | 2.0 | 65 | 6/26 | Medium | Shifting bottom | Mechanical weir & trap |
| Creek # 2 | Chippewa, 50-7-4 | 0.05 | 5.0 | 0.33 | Slight | 1.25 | 56-65 | 6/27-7/2 | Small | Shifting bottom | Mechanical weir & trap |

^{1/} List includes only those streams which appear to have a productive potential or for which control devices have been recommended.

^{2/} "Length" is the measurement of that portion of the stream surveyed, and is composed of a calculation of map distance plus application of a correction factor (variable) compiled from field measurements. The stream length figures differ from total length in all cases where barrier dams or field conditions terminated the area usable by sea lampreys short of the headwaters.

^{3/} Applicable only to the surveyed portion of the stream.

^{4/} From an engineering standpoint, electrical control devices can probably be installed in all streams for which mechanical devices have been recommended.

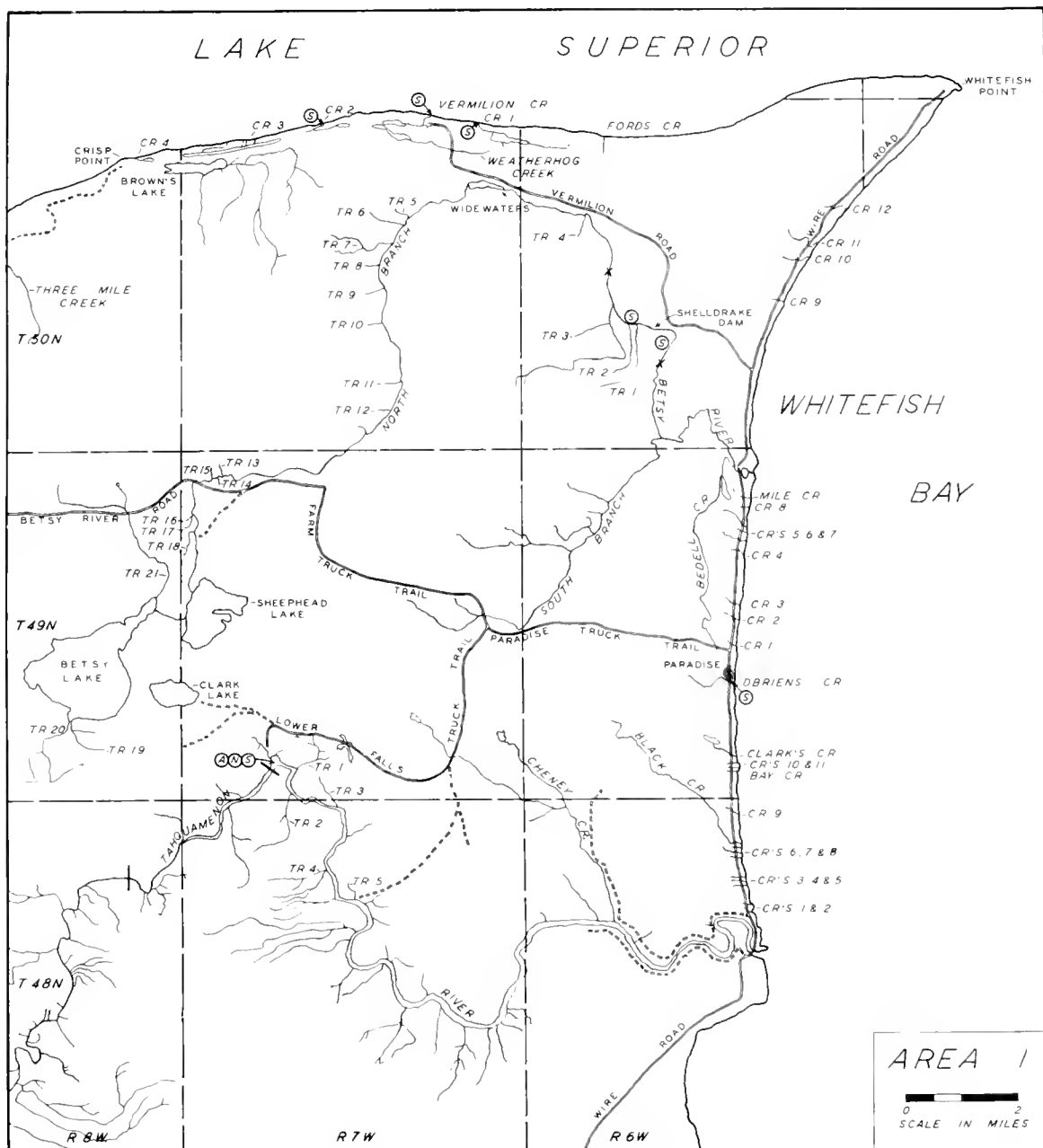


Figure 2.—Area 1.

Description of Area 1 (Fig. 2)

Embraces most of the western portion of Chippewa County, Mich., and contains a few large and numerous small coastal streams. Adult sea lampreys and nests were observed only in the Tahquamenon River just below the Lower Falls. Limited potential spawning habitat is present at that point and near the mouths of four small coastal streams (table 1). Potential spawning habitat is present to a greater extent in portions of the North Branch of the Betsy River. The Tahquamenon River is much too large for mechanical control devices; an electrical control device is recommended. Although it is much smaller, the Betsy River presents a similar problem. Creeks Nos. 1 and 2 are relatively inaccessible. All but a very few of the streams are brown in color, of relatively low velocity, and sandy-bottomed. Most of them drain extensive bogs and swamps, and flow through thick tag alder flood plains. The soil, which is generally sandy and poor, supports a jackpine - white pine - popple climax type. Topography is gentle.

Table 2.--Productive potential, recommended control devices,
and miscellaneous factors concerning streams in Area 2
(Survey made in 1950)

| Name of stream ^{1/} | County, township line, range, and section no. at mouth | Length of stream in miles ^{2/} | Average width of stream in ft. ^{3/} | Average depth of stream in ft. ^{3/} | Range in gradient ^{3/} in ft. ^{3/} per 1,000 ft. | Range in velocity in ft./sec. ^{3/} | Tempera- tures in degrees F. ^{3/} | Date | Productive potential | Possible limiting factors | Type of control possible ^{4/} |
|------------------------------|--|---|---|---|---|---|--|---------|-------------------------|---|--|
| Three Mile Creek | Luce, 50-8-16 | 5.0 | 8.0 | 0.66 | Slight | 0.75-1.25 | 50-54 | 7/2-7/3 | Medium | Spawning sites, temperature, velocity | Mechanical weir & trap |
| Little Two Hearted R. | Luce, 50-9-24 | 32.0 | 20.0 | 2.0 | Slight | 1.0-2.0 | 53-76 | 7/4-7/8 | Medium | Spawning sites, sifting bottom, temperature | Electrical |

^{1/} List includes only those streams which appear to have a productive potential or for which control devices have been recommended.

^{2/} "Length" is the measurement of that portion of the stream surveyed, and is composed of a calculation of map distance plus application of a correction factor (variable) compiled from field measurements. The stream length figures differ from total length in all cases where field conditions terminated the area usable by sea lampreys short of the headwaters.

^{3/} Applicable only to the surveyed portion of the stream.

^{4/} From an engineering standpoint, electrical control devices can probably be installed in all streams for which mechanical devices have been recommended.

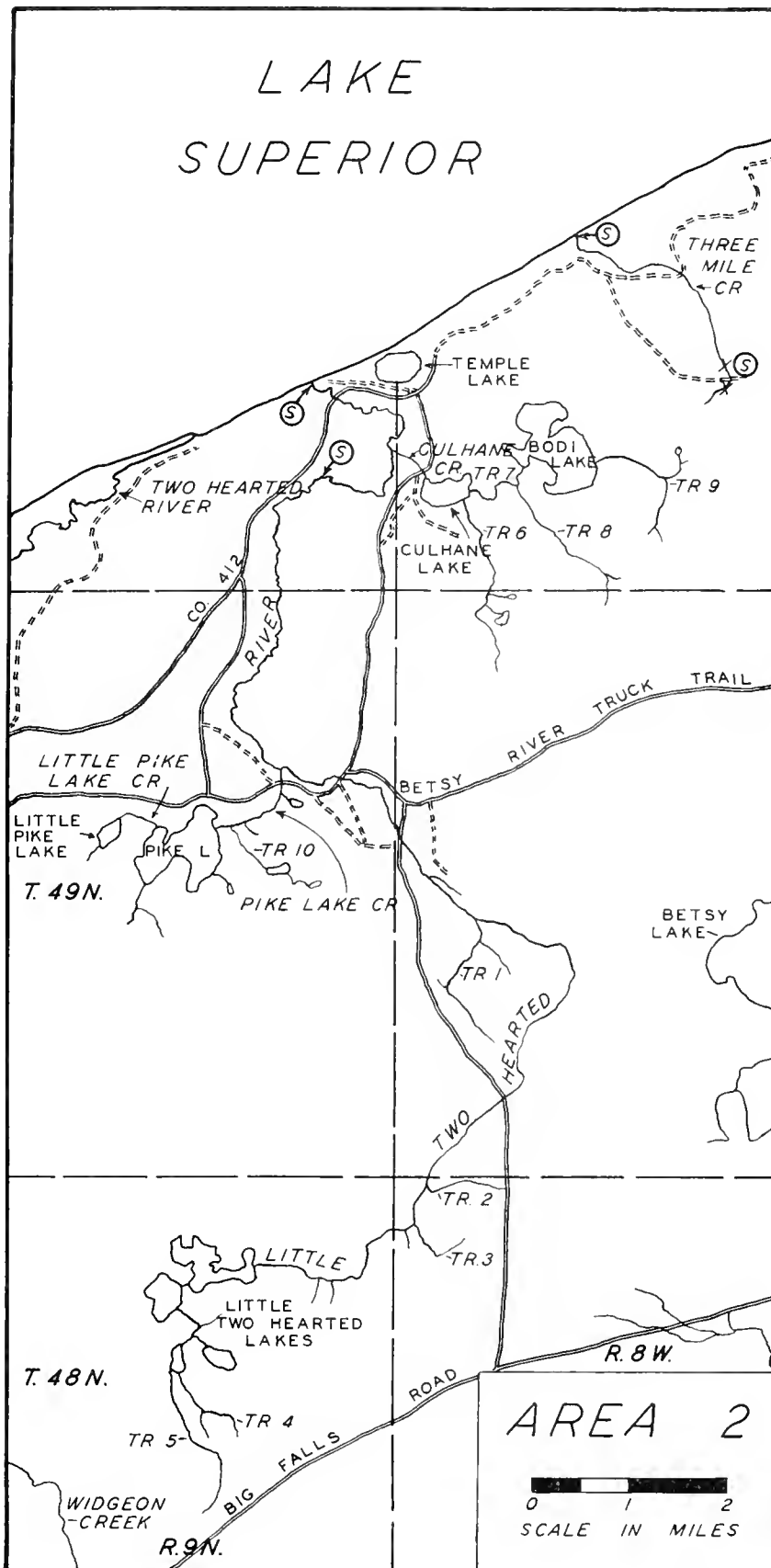


Figure 3.—Area 2.

Description of Area 2 (Fig. 3)

Embraces a portion of eastern Luce County, Mich., and contains only two streams and their tributaries. No adult sea lampreys or nests were observed, but both main streams contained potential spawning habitat. The Little Two Hearted River is probably too large for practical mechanical control, and an electrical device is recommended. The streams in the area are generally brown in color, of relatively low velocity, and sandy-bottomed; they flow through flood plains covered with a dense growth of tag alder. The soil is sandy and poor, and the forest climax type is predominantly coniferous. The topography is low and accordingly much of the area consists of bogs and swamps.

Table 3.--Productive potential, recommended control devices,
and miscellaneous factors concerning streams in Area 3
(Survey made in 1950)

| Name of stream ^{1/} | County, township line, range, and section no. at mouth | Length of stream in miles ^{2/} | Average width of stream in ft. ^{3/} | Average depth of stream in ft. ^{3/} | Range in gradient ^{3/} | Range in velocity in ft./sec. ^{3/} | Tempera- tures in degrees F. ^{3/} | Date | Productive potential | Possible limiting factors | Type of control possible ^{4/} |
|------------------------------|--|---|--|--|------------------------------------|---|--|-----------|-------------------------|------------------------------|--|
| Two Hearted River | Luce, 50-9-27 | 10.0 | 50.0 | 4.0 | Slight | 1.0-3.0 | 53-68 | 7/11-7/13 | Large | Temperature | Electrical |
| E. Br. Two Hearted R. | Luce, 50-10-1 | 25.0 | 25.0 | 1.5 | Slight | Sluggish-3.0 | 51-72 | 7/11-7/22 | Large | Temperature | ^{5/} |
| A. Br. Two Hearted R. | Luce, 49-9-6 | 50.0 | 30.0 | 3.0 | Slight-moderate | 1.5 | 53-65 | 7/13-7/31 | Large | Temperature | ^{5/} |
| Dawson Creek | Luce, 49-10-29 | 20.0 | 15.0 | 1.0 | Slight-moderate | Sluggish-2.25 | 56-61 | 7/25-7/28 | Large | Temperature | ^{5/} |
| N. Br. Two Hearted R. | Luce, 48-11-1 | 30.0 | 10.0 | 0.66 | Slight | Sluggish-1.0 | 57-65 | 7/28-8/3 | Medium | Temperature | ^{5/} |
| Dead Sucker River | Luce, 50-11-34 | 8.0 | 20.0 | 1.0 | Slight | Sluggish-2.5 | 56-65 | 8/5 | Medium | Velocity | Electrical |

^{1/} List includes only those streams which appear to have a productive potential or for which control devices have been recommended.

^{2/} "Length" is the measurement of that portion of the stream surveyed, and is composed of a calculation of map distance plus application of a correction factor (variable) compiled from field measurements. The stream length figures differ from total length in all cases where field conditions terminated the area usable by sea lampreys short of the headwaters.

^{3/} Applicable only to the surveyed portion of the stream.

^{4/} From an engineering standpoint, electrical control devices can probably be installed in all streams for which mechanical devices have been recommended.

^{5/} Stream tributary to another upon which it would be more practical to place a control device.

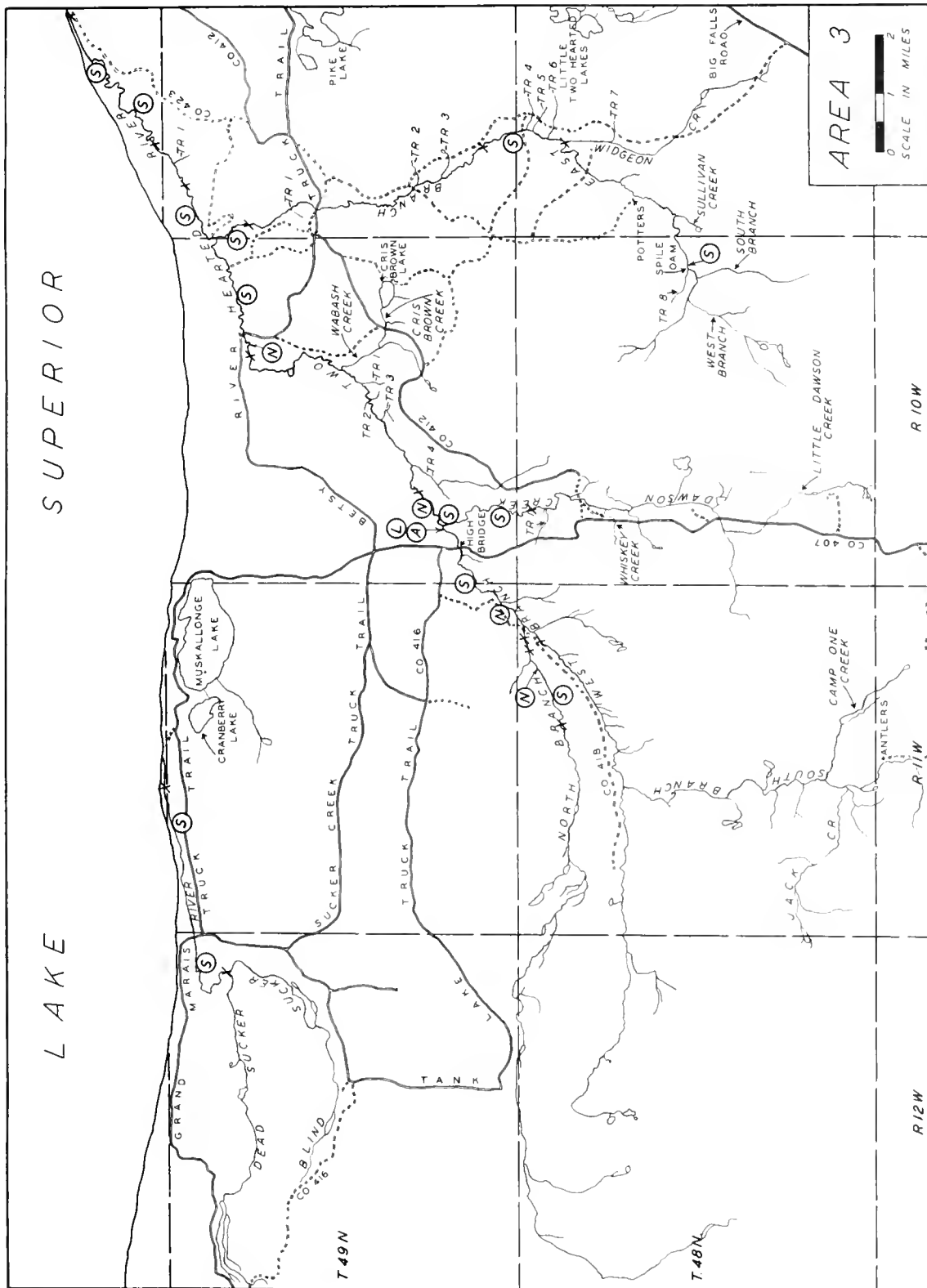


Figure 4.--Area 3.

Description of Area 3 (Fig. 4)

Embraces the northern portion of western Luce County, Mich., and contains only two streams, both of which are large. Limited amounts of potential spawning habitat are present in the Dead Sucker River. Unlimited facilities for spawning are present throughout much of the Two Hearted River system; several adults, larvae, and over 60 nests were observed in 1950 in this watershed. Both streams are too large for practical mechanical control devices; electrical devices are recommended. The Dead Sucker River is clear and of relatively low velocity; it drains an extensive low area of bogs and swamps. The streams of the Two Hearted River system are brown in color and of moderate water velocity; they flow through flood plains covered with dense stands of tag alder and drain extensive bogs and swamps. The topography is low. The soil is sandy and poor and accordingly the forest climax type is predominantly coniferous.

Table 4.--Productive potential, recommended control devices,
and miscellaneous factors concerning streams in Area 4
(Survey made in 1950)

| Name of stream ^{1/} | County, township line, range, and section no. at mouth | Length of stream in miles ^{2/} | Average width of stream in ft. ^{3/} | Average depth of stream in ft. ^{3/} | Range in gradient ^{3/} | Range in velocity in ft./sec. ^{3/} | Temper- atures in degrees F. ^{3/} | Date | Productive potential | Possible limiting factors | Type of control possible ^{4/} |
|------------------------------|--|---|---|---|------------------------------------|---|--|----------|-------------------------|---|--|
| Sucker River | Alger, 49-13-4 | 30.0 | 25.0 | 1.0 | Slight-moderate | 1.0-5.0 | 52-65 | 8/7-8/18 | Large | Velocity, temperature | Electrical |
| Baker Creek | Alger, 49-13-4 | 7.0 | 10.0 | 0.66 | Slight | 0.75-1.0 | --- | --- | Small | Spawning sites, temperature | Mechanical weir & trap |
| Creek # 1 | Alger, 49-13-5 | 0.3 | 1.5 | 0.12 | Slight-moderate | 1.0-2.0 | 59-67 | 8/9 | Small | Temperature, gradients | Mechanical weir & trap |
| Creek # 3 | Alger, 49-13-6 | 0.75 | 5.0 | 0.16 | Slight-moderate | 1.0 | 57-60 | 8/9 | Small | Temperature, gradients | Mechanical weir & trap |
| Creek # 4 | Alger, 49-13-6 | 0.3 | 1.0 | 0.08 | Slight-moderate | 0.5 | 55 | 8/9 | Small | Width, depth, temperature | Mechanical weir & trap |
| Sable Creek | Alger, 49-14-2 | 0.5 | 15.0 | 1.0 | Slight-moderate | 1.25-2.0 | 64 | 8/9 | Medium | Spawning sites, velocity, temperature | Electrical |

^{1/} List includes only those streams which appear to have a productive potential or for which control devices have been recommended.

^{2/} "Length" is the measurement of that portion of the stream surveyed, and is composed of a calculation of map distance plus application of a correction factor (variable) compiled from field measurements. The stream length figures differ from total length in all cases where field conditions terminated the area useable by sea lampreys short of the headwaters.

^{3/} Applicable only to the surveyed portion of the stream.

^{4/} From an engineering standpoint, electrical control devices can probably be installed in all streams for which mechanical devices have been recommended.

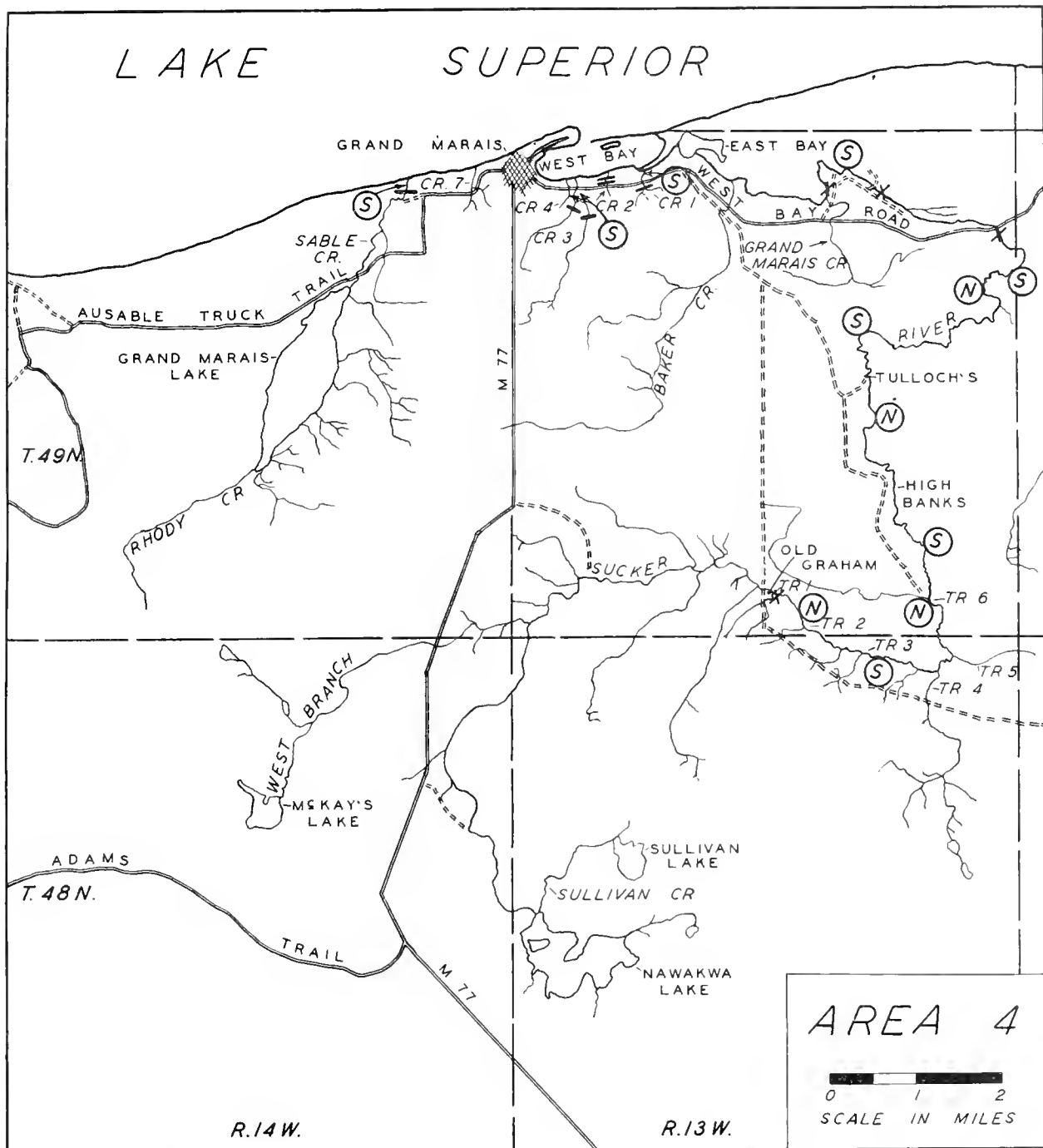


Figure 5.--Area 4.

Description of Area 4 (Fig. 5)

Embraces the northeast portion of Alger County, Mich., and contains six streams which are accessible to the sea lamprey. Sea lamprey nests were observed in the Sucker River in 1950. Extensive spawning habitat is present in that river and to a limited extent in Baker Creek, Creeks Nos. 1, 3, and 4, and Sable Creek. The Sucker River is too large for a practical mechanical control device; an electrical device is recommended. Mechanical control devices can be constructed in the remaining streams, but fluctuations in water volumes may be a problem. The streams in the area are generally brown in color and of moderate velocity; they flow through flood plains covered with heavy stands of tag alder, hardwoods and cedar. The topography is, as a rule, gentle; an exception is the steep shoreline of former glacial Lake Nipissing, just south of West Bay and the mouth of Sable Creek. The soil is sandy and poor, and accordingly the forest climax type is predominantly coniferous. Much of the area is cut and burned over.

Table 5.--Productive potential, recommended control devices,
and miscellaneous factors concerning streams in Area 5
(Survey made in 1950)

| Name of stream ^{1/} | County, township line, range, and section no. at mouth | Length of stream in miles ^{2/} | Average width of stream in ft. ^{3/} | Average depth of stream in ft. ^{3/} | Range in gradient ^{3/} | Range in velocity in ft./sec. ^{3/} | Tempera- ture in degrees F. ^{3/} | Date | Productive Potential | Possible limiting factors | Type of control possible ^{4/} |
|------------------------------|--|--|---|---|------------------------------------|---|---|------|-------------------------|--|--|
| Hurricane Creek | Alger, 49-15-3 | 12.0 | 20.0 | 1.0 | Slight-steep | 1.0-5.0 | --- | --- | Large | Velocity, gradient, and temperature | Mechanical weir & trap |
| Sullivan Creek | Alger, 49-15-9 | 6.0 | 5.0 | 0.58 | Slight-moderate | 1.0-4.0 | --- | --- | Medium | Temperature | Mechanical weir & trap |
| Seven Mile Creek | Alger, 49-16-25 | 10.0 | 20.0 | 1.0 | Slight-moderate | Sluggish-3.0 | --- | --- | Large | Temperature | Mechanical weir & trap |
| Lowney Creek | Alger, 49-16-17 | 3.0 | 15.0 | 1.0 | Slight-moderate | Sluggish-1.0 | 50 | 9/10 | Medium | Temperature | ^{5/} |
| Tributary # 7 | Alger, 49-16-17 | 4.0 | 6.0 | 0.5 | Slight | 1.25 | 56 | 9/10 | Medium | Temperature | ^{5/} |
| Tributary # 6 | Alger, 49-16-13 | 3.5 | 6.0 | 0.25 | Slight-steep | 1.0-2.0 | 54 | 9/4 | Medium | Gradient, velocity, and temperature | ^{5/} |
| Tributary # 5 | Alger, 49-17-13 | 3.5 | 4.0 | 0.5 | Slight-moderate | 0.75-1.0 | 49-55 | 9/10 | Small | Temperature | ^{5/} |

^{1/} List includes only those streams which appear to have a productive potential or for which control devices have been recommended.

^{2/} "Length" is the measurement of that portion of the stream surveyed, and is composed of a calculation of map distance plus application of a correction factor (variable) compiled from field measurements. The stream length figures differ from total length in all cases where field conditions terminated the area usable by sea lampreys short of the headwaters.

^{3/} Applicable only to the surveyed portion of the stream.

^{4/} From an engineering standpoint, electrical control devices can probably be installed in all streams for which mechanical devices have been recommended.

^{5/} Stream tributary to another upon which it would be more practical to place a control device.

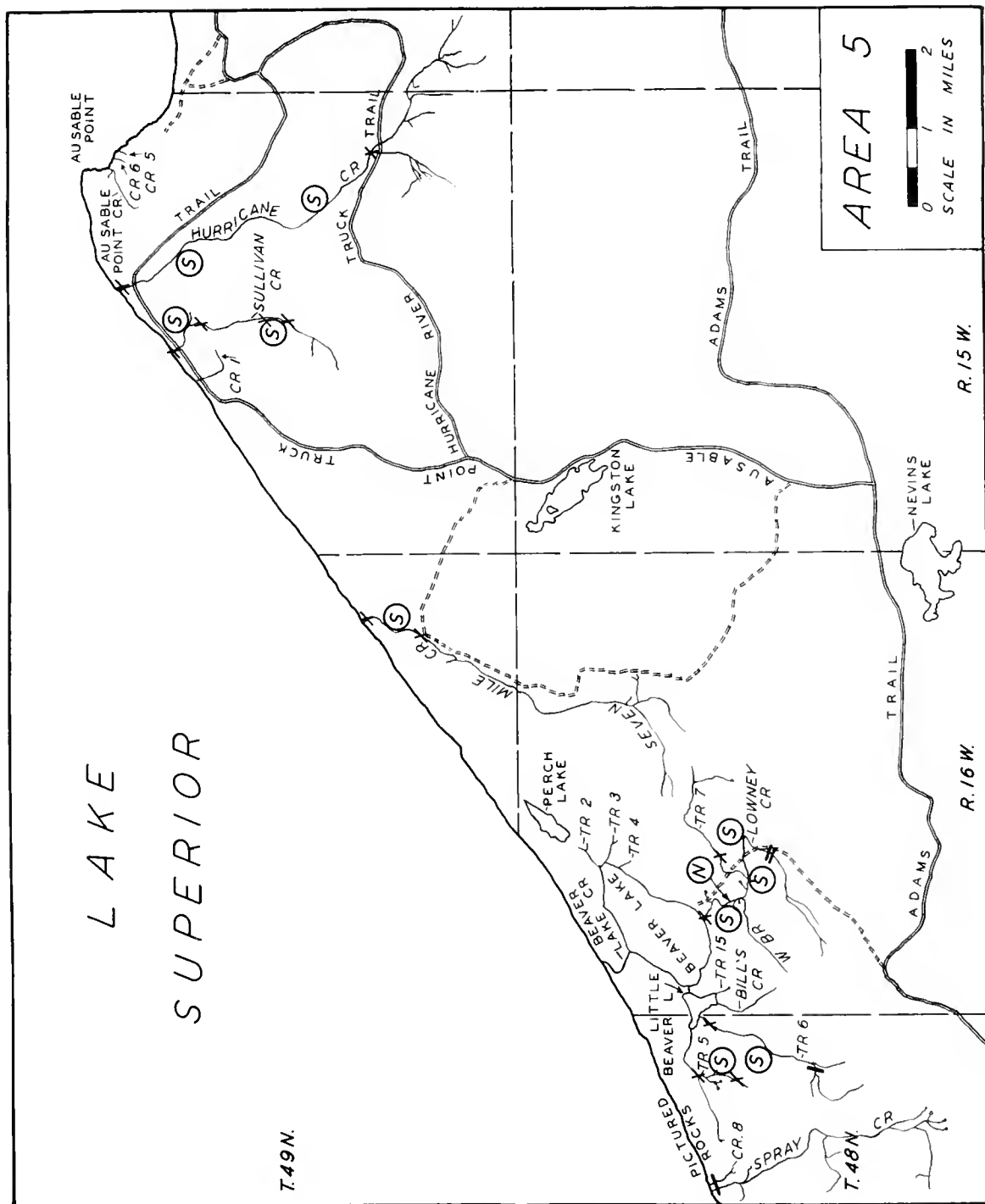


Figure 6.—Area 5.

Description of Area 5 (Fig. 6)

Embraces the north-central portion of Alger County, Mich., and contains at least seven streams in which spawning facilities are accessible to upstream migrants (table 5). Mechanical control devices can be constructed in Hurricane, Sullivan, and Seven Mile Creeks. The latter is relatively inaccessible. Migrations to the streams of the Beaver Lake watershed can be controlled by a device in Beaver Lake Creek; most of the streams in this system are relatively inaccessible. Stream gradients are slight to steep and water velocities vary accordingly. Beaver Lake Creek is interesting in that it forms an exact line of demarcation between the low, sandy country extending east to the Tahquamenon River and the more rugged sandy-loam country (often overlying bedrock) which is predominant to the west. Gradients are steep and velocities are higher in many of the western streams. Hardwoods are predominant on the better soils

Table 6.--Productive potential, recommended control devices,
and miscellaneous factors concerning streams in Area 6
(Survey made in 1950)

| Name of stream 1/ | County, township line, range, and section no. at mouth | Length of stream in miles 2/ | Average width of stream in ft. 3/ | Average depth of stream in ft. 3/ | Range in gradient 3/ | Range in velocity in ft./sec. 3/ | Tempera- tures in degrees F. | Date | Productive potential | Possible limiting factors | Type of control possible 4/ |
|-------------------|--|--|---|---|-------------------------|--|------------------------------------|-----------|-------------------------|---|-----------------------------------|
| Chapel Lake Creek | Alger, 48-17-21 | 1.0 | 18.0 | 2.0 | Slight-moderate | Sluggish-1.0 | 58 | 9/11 | Medium | Scouring at mouth, partial barrier, temperature | Mechanical weir & trap |
| Tributary # 13 | Alger, 48-17-28 | 0.25 | 20.0 | 0.33 | Slight-steep | 1.0-3.0 | --- | --- | Small | Gradient, velocity, temperature | 5/ |
| Tributary # 16 | Alger, 48-17-29 | 2.0 | 4.0 | 0.33 | Slight-steep | Sluggish-3.0 | 48-50 | 9/14 | Medium | Gradient, velocity, temperature | 5/ |
| Mosquito River | Alger, 48-18-25 | 3.0 | 15.0 | 0.5 | Slight-steep | 1.0-3.0 | 53 | 9/14 | Large | Velocity, temperature | Mechanical weir & trap |
| Tributary # 17 | Alger, 48-18-31 | 0.25 | 5.0 | 0.12 | Slight-moderate | 1.0-3.0 | 51 | 9/14 | Small | Velocity, temperature | 5/ |
| Miners River | Alger, 47-18-3 | 4.0 | 15.0 | 0.5 | Slight-moderate | 0.75-1.25 | 50-60 | 9/7-9/8 | Large | Temperature | Mechanical weir & trap |
| Creek # 22 | Alger, 47-18-30 | 0.75 | 2.0 | 0.08 | Slight-steep | 0.75-1.25 | 46-50 | 9/16-9/18 | Small | Gradient, velocity, temperature | Mechanical weir & trap |
| Creek # 23 | Alger, 47-19-36 | 0.25 | 2.0 | 0.08 | Slight-steep | 0.75-1.25 | 46 | 9/16 | Small | Gradient, velocity, temperature | Mechanical weir & trap |
| Creek # 24 | Alger, 47-19-36 | 0.25 | 2.0 | 0.08 | Slight-steep | 0.75-1.25 | 48 | 9/16 | Small | Gradient, velocity, temperature | Mechanical weir & trap |
| Creek # 25 | Alger, 47-19-36 | 0.5 | 4.0 | 0.33 | Slight-moderate | Sluggish-0.75 | 51 | 9/16-9/18 | Small | Gradient, velocity, temperature | Mechanical weir & trap |
| Creek # 26 | Alger, 46-19-1 | 0.5 | 2.0 | 0.16 | Slight-steep | 0.75-1.25 | 46-50 | 9/16-9/18 | Small | Gradient, velocity, temperature | Mechanical weir & trap |
| Creek # 27 | Alger, 46-19-1 | 0.25 | 3.0 | 0.25 | Slight-steep | 0.75-1.25 | 46-48 | 9/16-9/18 | Small | Gradient, velocity, temperature | Mechanical weir & trap |
| Anne River | Alger, 46-19-2 | 10.0 | 10.0 | 1.0 | Slight | 0.75-2.0 | 46-50 | 9/16-9/28 | Medium | Temperature | Electrical |
| Wagner Creek | Alger, 46-19-11 | 0.3 | 10.0 | 0.25 | Slight-steep | 1.0-3.0 | 50 | 9/16 | Medium | Gradient, velocity, temperature | 5/ |
| Purnace Creek | Alger, 47-19-29 | 0.75 | 12.0 | 1.0 | Slight-moderate | Sluggish-3.0 | 54 | 9/19 | Large | Temperature, velocity | Electrical |
| Gougeon Creek | Alger, 47-19-29 | 4.0 | 6.0 | 0.5 | Slight-steep | 0.75-2.0 | 51-52 | 9/28-9/30 | Medium | Temperature, velocity | 5/ |
| Hanson Creek | Alger, 47-19-29 | 6.0 | 10.0 | 0.5 | Slight-steep | Sluggish-2.0 | 50-53 | 9/20 | Medium | Gradient, velocity, temperature | 5/ |
| Tributary # 5 | Alger, 47-20-25 | 0.3 | 2.0 | 0.04 | --- | 0.75-1.0 | 48-49 | 9/20 | Small | Temperature | 5/ |
| Creek # 6 | Alger, 47-19-19 | 2.0 | 2.0 | 0.25 | Slight | Sluggish | 51 | 9/19 | Small | Temperature | Mechanical weir & trap |
| Creek # 7 | Alger, 47-19-18 | 0.75 | 4.0 | 0.33 | Slight | Sluggish-0.75 | 53 | 9/18 | Small | Temperature, dry stream bed | Mechanical weir & trap |

1/ List includes only those streams which appear to have a productive potential or for which control devices have been recommended.

2/ "Length" is the measurement of that portion of the stream surveyed, and is composed of a calculation of map distance plus application of a correction factor (variable) compiled from field measurements. The stream length figures differ from total length in all cases where field conditions terminated the area usable by sea lampreys short of the headwaters.

3/ Applicable only to the surveyed portion of the stream.

4/ From an engineering standpoint, electrical control devices can probably be installed in all streams for which mechanical devices have been recommended.

5/ Stream tributary to another upon which it would be more practical to place a control device.

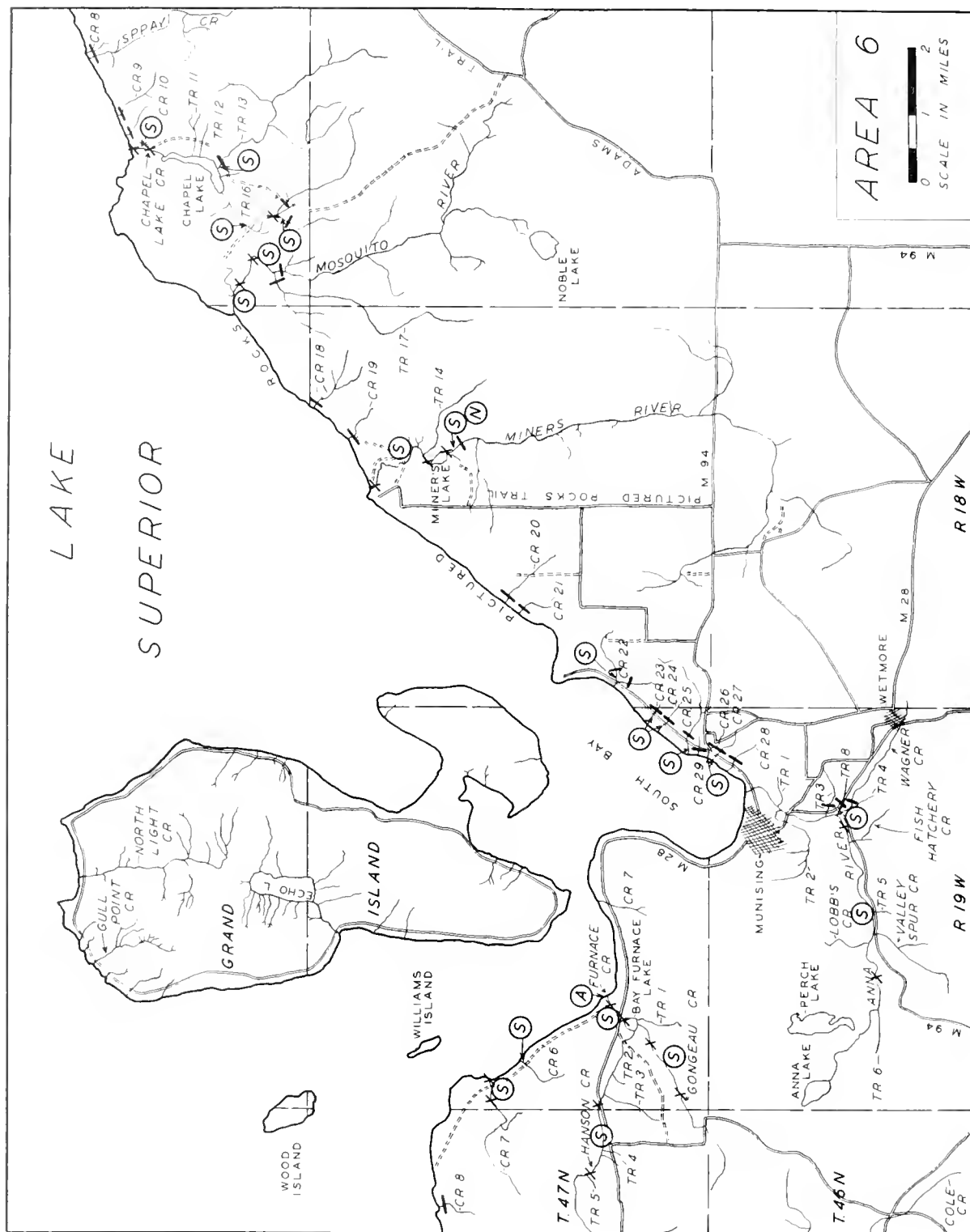


Figure 7.—Area 6.

Description of Area 6 (Fig. 7)

Embraces a portion of northwestern Alger County, Mich., and contains at least one stream which was utilized by sea lampreys in 1950. Nests were observed in Miner's River; dead adults were observed at the mouth of Furnace Creek. Both streams have a large productive potential; a mechanical weir is recommended for Miner's River and an electrical device for Furnace Creek. Fifteen other streams contain spawning facilities. Chapel Lake Creek and the Mosquito River are relatively inaccessible. The streams of the area are both clear and brown in color; gradients range from slight to steep and velocities vary accordingly. The bottoms of several streams are irregular due to the presence of rubble, boulders, and bedrock. The topography of the area is relatively rugged. The sandy-loam soil overlies a bedrock substratum. Hardwoods are predominant. Grant Island which lies off the shore of Area 6 has not been examined.

Table 7.--Productive potential, recommended control devices,
and miscellaneous factors concerning streams in Area 7
(Survey made in 1950)

| Name of stream ^{1/} | County, township line, range, and section no. at mouth | Length of stream in miles ^{2/} | Average width of stream in ft. ^{3/} | Average depth of stream in ft. ^{3/} | Range in gradient ^{3/} in ft. ^{3/} per 100 ft. | Range in velocity in ft./sec. ^{3/} | Tempera- tures in degrees F. | Date | Productive potential | Possible limiting factors | Type of control possible ^{4/} |
|------------------------------|--|---|--|--|---|---|------------------------------------|-----------|-------------------------|------------------------------------|--|
| Creek # 10 | Alger, 47-20-28 | 0.1 | 5.0 | 0.25 | Slight-steep | Sluggish-1.0 | --- | --- | Small | Gradient, velocity | Electrical |
| Au Train River (lower) | Alger, 47-20-29 | 10.0 | 100.0 | 3.0 | Slight | Sluggish | 59 | 9/30 | Medium | None | 5/ |
| Joel's Creek | Alger, 47-20-32 | 6.0 | 6.0 | 0.5 | Slight-steep | 1.0-2.25 | 51-52 | 9/27-9/28 | Medium | Gradient, temperature | 5/ |
| Cole Creek | Alger, 46-20-8 | 9.0 | 7.0 | 0.5 | Slight | 0.75 | 48-51 | 9/22 | Medium | Temperature | 5/ |
| Buck Bay Creek | Alger, 46-20-8 | 4.0 | 12.0 | 0.5 | Slight-moderate | 0.75 | 48 | 9/22 | Small | Temperature | 5/ |
| Tributary # 4 | Alger, 46-20-16 | ? | 5.0 | 0.33 | --- | 1.0 | 48 | --- | Small | Temperature | 5/ |
| Addis Creek | Alger, 46-20-18 | 3.0 | 10.0 | 0.33 | Slight | 1.0-1.25 | 48 | --- | Medium | Temperature | 5/ |
| Au Train R. (upper) | Alger, 46-20-18 | 6.0 | 25.0 | Varies | --- | Varies | 47 | 10/4 | ? | Water level fluctuations | 5/ |
| Rock River | Alger, 47-21-15 | 22.0 | 20.0 | 0.66 | Slight-moderate | 1.0-1.25 | 53 | 9/21 | Large | Temperature, velocity | Electrical |
| Nelson Creek | Alger, 47-21-22 | 6.0 | 4.0 | 0.25 | Slight | 0.75-1.0 | 47 | 10/8 | Medium | Temperature | 5/ |
| Tributary # 1 | Alger, 47-21-27 | 3.0 | 3.0 | 0.5 | Slight-moderate | 1.0 | --- | --- | Small | Temperature, size | 5/ |
| Tributary # 2 | Alger, 47-21-27 | 6.0 | 4.0 | 0.25 | Slight-moderate | 1.0 | --- | --- | Small | Temperature, size | 5/ |
| Silver Creek | Alger, 46-21-15 | 10.0 | 8.0 | 0.5 | Slight-moderate | 0.75-1.0 | 47 | 10/7 | Medium | Temperature | 5/ |
| Tributary # 7 | Alger, 47-21-18 | 1.0 | 15.0 | 0.5 | Slight-steep | Sluggish | --- | --- | Small | Gradient, velocity, temperature | 5/ |
| Tributary # 8 | Alger, 47-21-18 | 1.5 | 15.0 | 0.5 | Moderate-steep | Sluggish | --- | --- | Small | Gradient, velocity, temperature | 5/ |
| Loughing Whitefish R. | Alger, 48-22-26 | 30.0 | 20.0 | 1.0 | Slight-moderate | Sluggish-4.0 | 47-55 | 9/21-10/6 | Large | Gradient, temperature | Electrical |

^{1/} List includes only those streams which appear to have a productive potential or for which control devices have been recommended.

^{2/} "Length" is the measurement of that portion of the stream surveyed, and is composed of a calculation of map distance plus application of a correction factor (variable) compiled from field measurements. The stream length figures differ from total length in all cases where field conditions indicated the area usable by see lampreys short of the headwaters.

^{3/} Applicable only to the surveyed portion of the stream.

^{4/} From an engineering standpoint, electrical control devices can probably be installed in all streams for which mechanical devices have been recommended.

^{5/} Stream tributary to another upon which it would be more practical to place a control device.

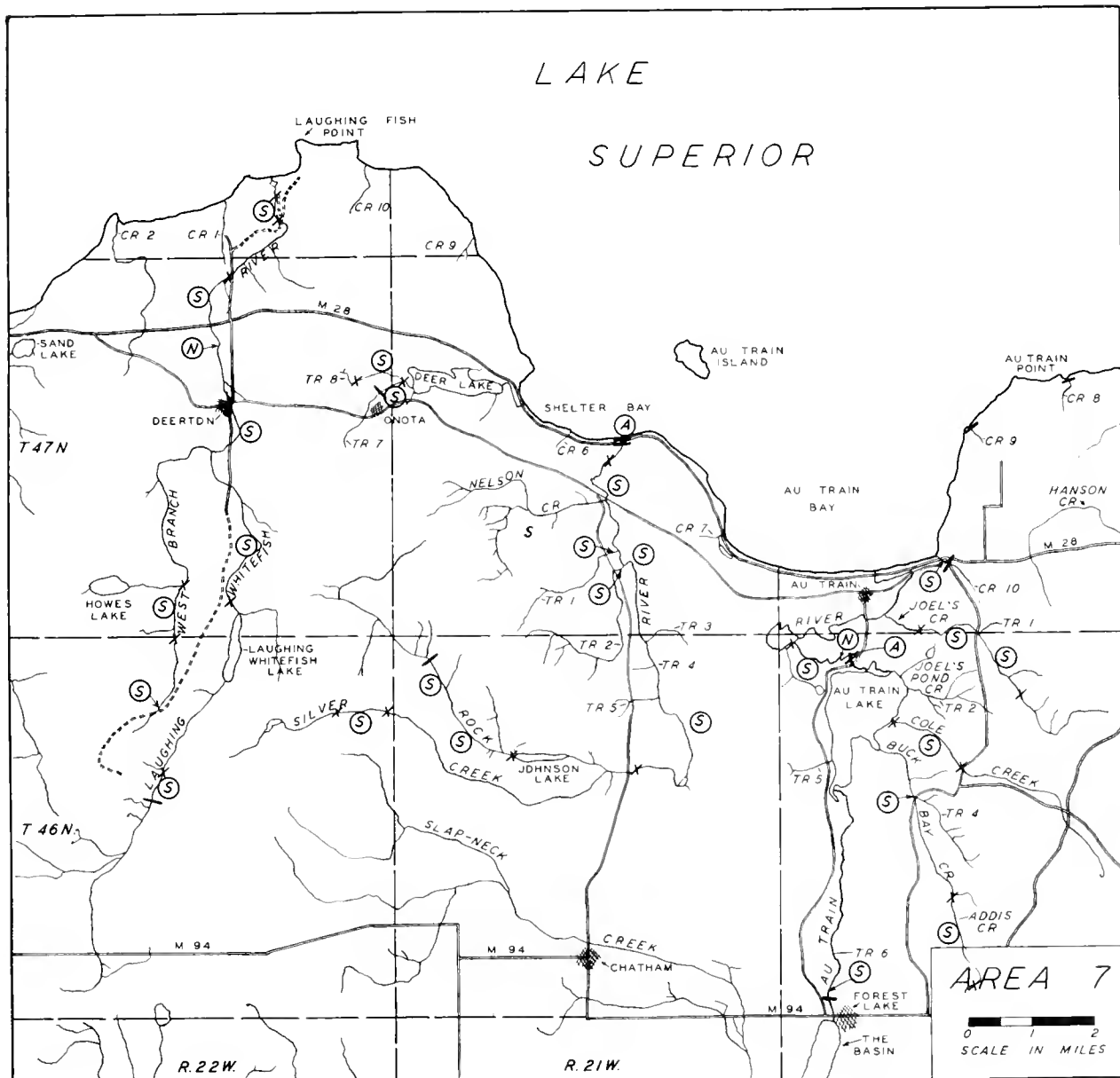


Figure 8.—Area 7.

Description of Area 7 (Fig. 8)

Embraces part of the northwestern portion of Alger County, Mich., and contains at least two streams which were utilized by sea lampreys in 1950. Nests were observed in the Au Train and Laughing Whitefish Rivers. Adult sea lampreys were seen in the Au Train and at the mouth of the Rock River. These three rivers are too large for practical mechanical control; electrical devices are recommended. Spawning facilities are present in 13 other streams, but, at present, control devices (mechanical) need be placed only in Creek No. 10 and Deer Lake Creek. The streams of the area are both clear and brown in color and gradients range from slight to steep. The bottoms of several streams are irregular due to the presence of rubble, boulders, and bedrock. The topography of the area is relatively rugged. The sandy-loam soil overlies a bedrock substratum. Hardwoods predominate.

Table 8.--Productive potential, recommended control devices,
and miscellaneous factors concerning streams in Area 8
(Survey made in 1950)

| Name of stream ^{1/} | County, township line, range, and section no. at mouth | Length of stream in miles ^{2/} | Average width of stream in ft. ^{3/} | Average depth of stream in ft. ^{3/} | Range in gradient ^{3/} | Range in velocity in ft./sec. ^{3/} | Temperatures in degrees F. | Date | Productive potential | Possible limiting factors | Type of control possible ^{5/} |
|------------------------------|--|---|--|--|---------------------------------|---|----------------------------|-------------|----------------------|----------------------------|--|
| Sand River | Alger, 47-22-6 | 20.0 | 33.0 | 1.0 | Slight | 0.25-1.75 | 52 | 10/7/50 | Medium | Temperature, velocity | Electrical |
| E. Br. Sand River | Marquette, 47-23-35 | 9.25 | 6.0 | 0.33 | Slight | 1.75 | 52 | 10/7/50 | Small | Temperature, obstacles | ^{5/} |
| Chocoley River | Marquette, 47-24-6 | 23.0 | 46.0 | 1.0 | Slight | 1.0-2.5 | 44-67 | 6/6-9/25/50 | Large | Level fluct., temperature? | Electrical |
| E. Br. Chocoley River | Marquette, 46-24-14 | 3.3 | 22.5 | 0.9 | Moderate | 1.5 | 51-52 | 9/14,15/50 | Medium | Temperature, level fluct. | ^{5/} |
| W. Br. Chocoley River | Marquette, 46-24-14 | 4.0 | 20.0 | 0.9 | Slight-steep | 1.5-2.25 | 54-56 | 8/24/50 | Small | Obstacles, temperature | ^{5/} |

^{1/} List includes only those streams which appear to have a productive potential or for which control devices have been recommended.

^{2/} "Length" is the measurement of that portion of the stream surveyed, and is composed of a calculation of map distance plus application of a corrective factor (variable) compiled from field measurements. The stream length figures differ from total length in all cases where field conditions terminated the area usable by sea lampreys short of the headwaters.

^{3/} Applicable only to the surveyed portion of the stream.

^{4/} From an engineering standpoint, electrical control devices can probably be installed in all streams for which mechanical devices have been recommended.

^{5/} Stream tributary to another upon which it would be more practical to place a control device.

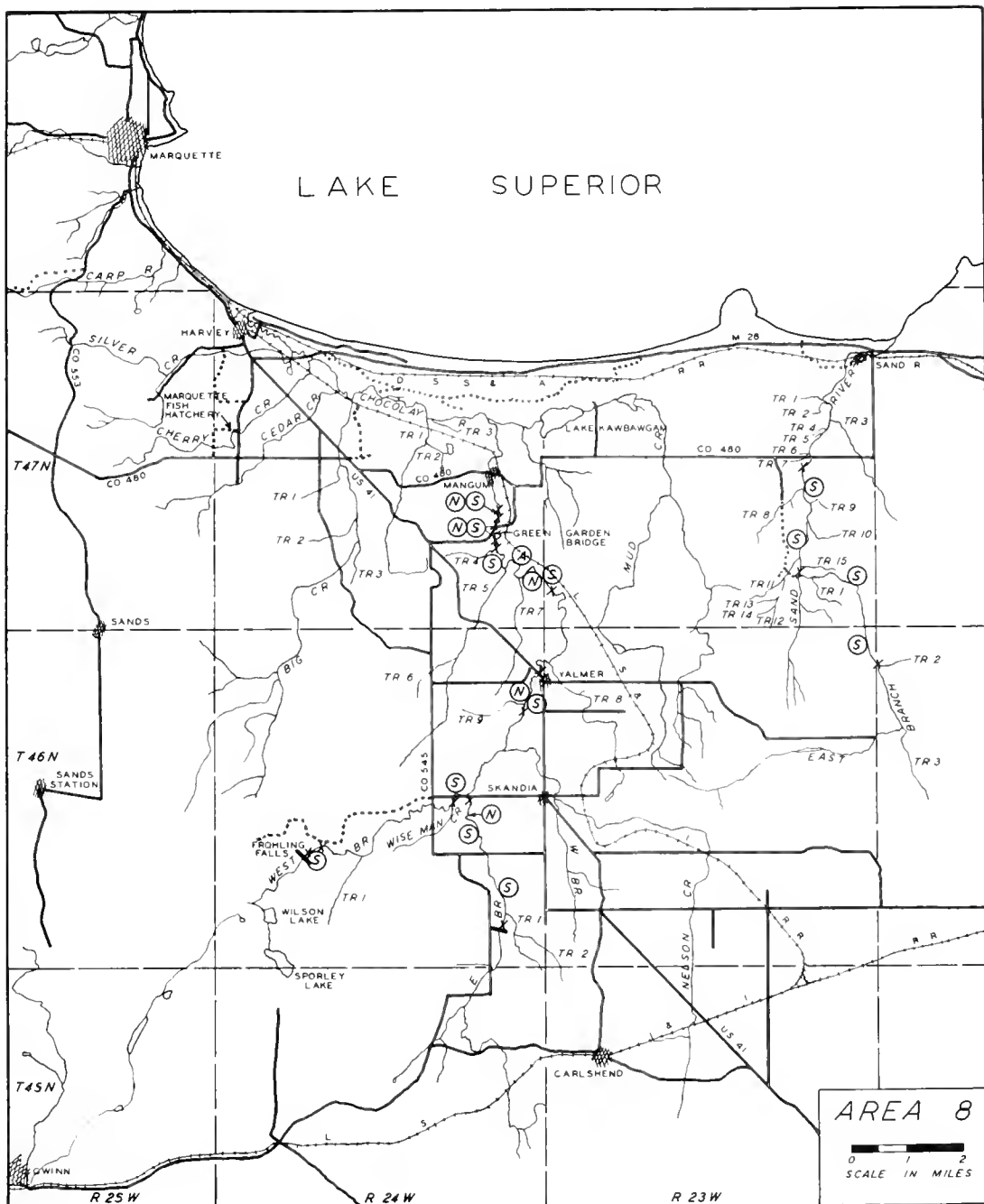


Figure 9.—Area 8

Description of Area 8 (Fig. 9)

Embraces the northeast portion of Marquette County, Michigan, and the watersheds of the Sand and Chocoday Rivers. Nests and adults were observed in considerable numbers in the Chocoday; both streams contain appreciable amounts of spawning facilities. Control by electrical devices is recommended. The streams of the area are brown in color and gradients range from slight to steep. The area is characterized by rolling to rugged topography, sandy to gravely moraines, fairly rich soils, and mixed northern hardwood forest.

Table 9.--Productive potential, recommended control devices,
and miscellaneous factors concerning streams in Area 9
(Survey made in 1950)

| Name of stream ^{1/} | County, township line, range, and section no. at mouth | Length of stream in miles ^{2/} | Average width of stream in ft. ^{3/} | Average depth of stream in ft. ^{3/} | Range in gradient ^{3/} | Range in velocity in ft./sec. ^{3/} | Temperatures in degrees F. | Productive potential | Possible limiting factors | Type of control possible ^{4/} |
|------------------------------|--|---|---|---|------------------------------------|---|-------------------------------|-------------------------|--|--|
| Carp River | Marquette, 48-25-36 | 10.0 | 37.5 | 0.9 | Slight-steep | 0.5-2.5 | 44-45 | Medium | Level fluct., temperature, pollution | Electrical |
| Harlow Creek | Marquette, 49-25-20 | 13.0 | 15.0 | 0.5 | Slight-moderate | Up to 1.0 | 57 | Small | Spawning sites, velocity, obstacles | Mechanical weir & trap |
| Blomark Creek | Marquette, 49-26-24 | 8.5 | 15.0 | 0.5 | Slight-steep | 2.25 | 58 | Medium | Spawning sites, obstacles | 5/ |
| Little Garlic River | Marquette, 49-26-2 | 8.0 | 17.5 | 0.5 | Slight-steep | 1.0-1.75 | 55-57 | Medium | Spawning sites | Mechanical weir & trap |
| Big Garlic River | Marquette, 50-26-21 | 13.0 | 20.0 | 0.75 | Slight | 0.9-1.5 | 59 | None | Spawning materials, barrier falls | Mechanical weir & trap |

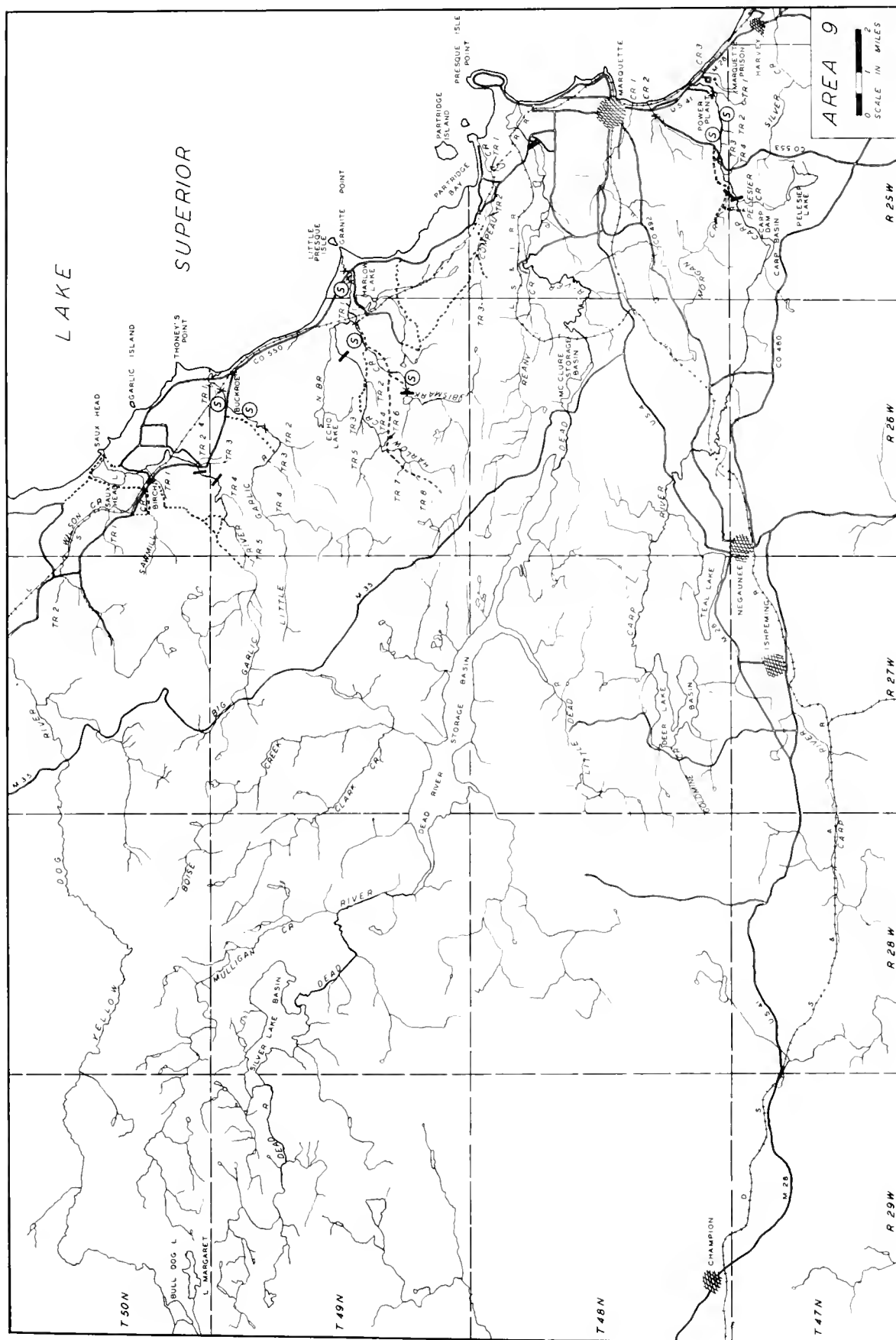
^{1/} List includes only those streams which appear to have a productive potential or for which control devices have been recommended.

^{2/} "Length" is the measurement of that portion of the stream surveyed, and is composed of a calculation of map distance plus a calculation of a corrective factor (variable) compiled from field measurements. The stream length figures differ from total length in all cases where field conditions terminated the area usable by see lampreys short of the headwaters.

^{3/} Applicable only to the surveyed portion of the stream.

^{4/} From an engineering standpoint, electrical control devices can probably be installed in all streams for which mechanical devices have been recommended.

^{5/} Stream tributary to another upon which it would be more practical to place a control device.



Description of Area 9 (Fig. 10)

Embraces the north central portion of Marquette County, Mich., and includes the Carp, Dead, Big Garlic, and Little Garlic Rivers, Harlow and Compeau Creeks, and several small coastal streams tributary to Lake Superior. All of these streams except the Dead River, with a barrier near its mouth, are potential lamprey producers but no evidence of utilization was observed. Electrical control devices are recommended for the Carp and Big Garlic, and mechanical structures for the other potentially productive streams. The streams in the area are generally clear and brown (the Carp tends to be turbid and polluted in the lower reaches). Gradients range from slight to steep. Hard bottom constituents in many forms are abundant. Rugged, rocky hill and moraine topography predominates except in the narrow coastal sand plain; soils are light to heavy sandy loams over bedrock. Northern hardwoods are predominant.

Table 10.--Productive potential, recommended control devices,
and miscellaneous factors concerning streams in Area 10
(Survey made in 1950)

| Name of stream ^{1/} | County, township line, range, and section no. at mouth | Length of stream in miles ^{2/} | Average width of stream in ft. ^{3/} | Average depth of stream in ft. ^{3/} | Range in gradient ^{3/} in ft. ^{3/} | Range in velocity in ft./sec. ^{3/} | Tempera- tures in degrees F. | Productive potential | Possible limiting factors | Type of control possible ^{4/} |
|------------------------------|--|---|--|--|--|---|------------------------------------|-------------------------|---|--|
| Iron River | Marquette, 51-26-18 | 3.0 | 60.0 | 1.5 | Slight | 1.5 | 60 | Small | Spawning sites | Electrical |
| Salmon Trout River | Marquette, 52-27-32 | 12.0 | 31.0 | 1.0 | Slight-steep | 1.0-2.5 | 51-54 | Medium | Temperature | Mechanical weir & trap |
| Fine River | Marquette, 52-28-21 | 3.0 | 30.0 | 1.5 | Slight | 1.0-2.0 | 56 | Medium | Spawning sites, temperature, and velocity | Electrical |
| Rush Creek | Marquette, 52-28-20 | 1.0 | 7.0 | 0.25 | Slight | Up to 1.0 | 58 | Small | Obstacles, velocity | <u>5/</u> |
| Mountain Stream | Marquette, 52-28-29 | 1.6 | 10.5 | 0.5 | Moderate-steep | 2 | 57 | Medium | Obstacles, temperature | <u>5/</u> |
| Little Huron River | Marquette, 52-29-17 | 7.0 | 9.0 | 0.5 | Slight-moderate | 1.5-1.75 | 43-44 | Medium | Spawning sites, temperature, obstacles | Mechanical weir & trap |

^{1/} List includes only those streams which appear to have a productive potential or for which control devices have been recommended.

^{2/} "Length" is the measurement of that portion of the stream surveyed, and is composed of a calculation of map distance plus application of a corrective factor (variable) short of the headwaters. The stream length figures differ from total length in all cases where field conditions terminated the area usable by sea lampreys

^{3/} Applicable only to the surveyed portion of the stream.

^{4/} From an engineering standpoint, electrical control devices can probably be installed in all streams for which mechanical devices have been recommended.

^{5/} Stream tributary to another upon which it would be more practical to place a control device.

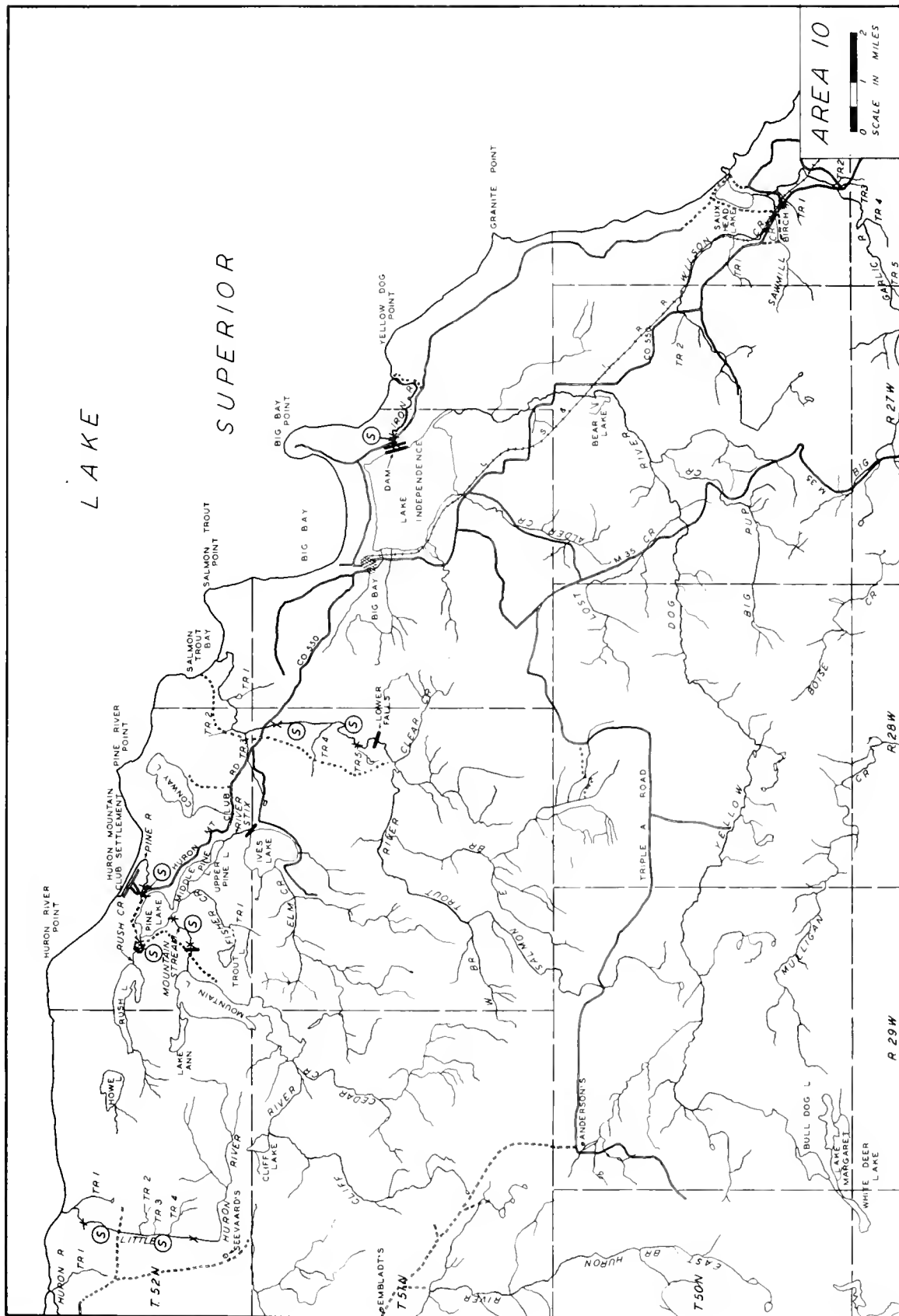


Figure 11.—Area 10.

Description of Area 10 (Fig. 11)

Embraces the northwestern portion of Marquette County, Mich., and contains the Yellow Dog-Iron, Salmon Trout, Pine, and Little Huron River watersheds. All have recognizable productive potentials but no evidence of past or present utilization exists. Electrical control devices are recommended for the Yellow Dog-Iron system and the Pine; mechanical structures are suitable for the Salmon Trout and Little Huron. Clear, organically brown streams typify the area. Gradients range from slight to steep. Hard-bottom materials are common but soft constituents occur frequently. Rugged, rocky mountainous wilderness characterizes the area. Morainic slopes and ridges occur commonly; soils are relatively rich, and overlay bedrock. Northern hardwoods and mixed growth predominate.

Table 11.--Productive potential, recommended control devices,
and miscellaneous factors concerning streams in Area 11
(Survey made in 1950)

| Name of stream | County, township line, range, and section no. at mouth | Length of stream in miles | Average width of stream in ft. | Average depth of stream in ft. | Range in gradient | Range in velocity in ft./sec. | Temperatures in degrees F. | Date | Productive potential | Possible limiting factors | Type of control possible |
|---------------------------------|--|---------------------------|--------------------------------|--------------------------------|-------------------|-------------------------------|----------------------------|-------------|----------------------|--|--------------------------|
| Huron River | Marquette, 52-29-18 | 12.0 | 31.5 | 1.0 | Slight-steep | 1.5-1.75 | 48-51 | 9/23 | Medium | Temperature, level fluctuations, obstacles | Electrical |
| E. Br. Huron River | Beraga, 50-30-35 | 4.75 | 25.0 | 0.33 | Moderate-steep | 2.0 | 48 | 9/21 | Medium | Temperature, level fluctuations, obstacles | 5/ |
| Trib. # 1 to E. Br. Huron River | Beraga, 51-30-1 | 2.5 | 10.0 | 0.33 | Slight-moderate | 1.75 | 48 | 9/21 | Small | Temperature, spawning sites | 5/ |
| A. Br. Huron River | Beraga, 52-30-35 | 5.0 | 12.0 | 0.66 | Moderate | 2.0 | --- | --- | Medium | Level fluctuations, temperature, obstacles | 5/ |
| Pavine River | Beraga, 51-31-4 | 10.0 | 21.5 | 0.5 | Moderate-steep | 0.75-2.0 | 62 | 6/31 | Large | Level fluctuations | Mechanical weir & trap |
| A. Br. Ravine River | Beraga, 51-31-2 | 6.75 | 6.0 | 0.75 | Moderate-steep | 2.0- ? | --- | --- | Small | Spawning sites, level fluctuations, temperature, obstacles | 5/ |
| Slate River | Beraga, 51-31-8 | 1.0 | 15.0 | 0.5 | Slight-steep | 0.5-1.75 | 50-63 | 8/31 & 9/12 | Medium | Spawning sites, level fluctuations, barriers | Electrical |
| Silver River | Beraga, 51-31-18 | 13.0 | 45.0 | 0.5 | Moderate-steep | 1.0-1.75 | 54 | 8/31 | Medium | Spawning sites, fluctuations, temperature, obstacles | Electrical |

1/ List includes only those streams which appear to have a productive potential or for which control devices have been recommended.

2/ "Length" is the measurement of that portion of the stream surveyed, and is composed of a calculation of map distance plus application of a corrective factor (variable) compiled from field measurements. The stream length figures differ from total length in all cases where field conditions terminated the area usable by sea lampreys short of the headwaters.

3/ Applicable only to the surveyed portion of the stream.

4/ From an engineering standpoint, electrical control devices can probably be installed in all streams for which mechanical devices have been recommended.

5/ Stream tributary to another upon which it would be more practical to place a control device.

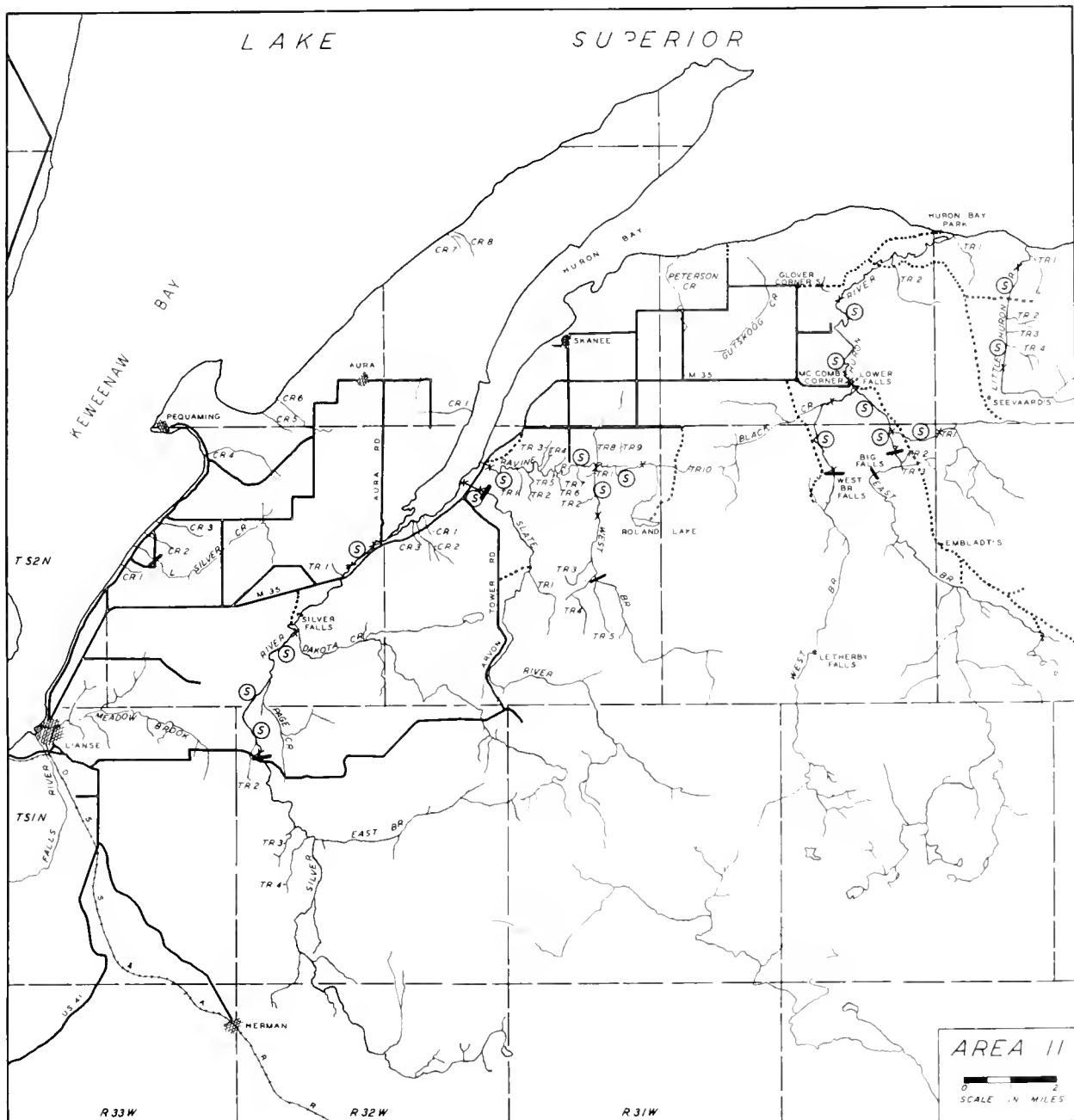


Figure 12.--Area 11.

Description of Area 11 (Fig. 12)

Embraces a section of the northern portion of Baraga County, Mich., and contains the Huron, Ravine, Slate, and Silver River watersheds, and several small coastal streams. All of these streams and their tributaries are potential sea lamprey producers, and in several of them rather questionable evidence of utilization was observed. Electrical control devices are recommended for the Huron, Slate, and Silver Rivers, and a mechanical structure for the Ravine. The streams of the area are brown in color. Gradients range from slight to steep, and surface velocities vary accordingly. Hard-bottom components of frequently inferior character (as spawning material) are common. Glaciated rocky terrain typifies much of the area, particularly in the east, but old lake sands and wet lowlands are more common to the west and along the Superior shore. Mixed growth composed of dominant hardwoods and some scrub popple forms the forest cover.

Table 12.--Inductive potential, recommended control devices,
and miscellaneous factors concerning streams in Area 12
(Survey made in 1950)

| Name of stream ^{1/} | County, township line, range, and section no. at mouth | Length of stream in miles ^{2/} | Average width of stream in ft. ^{3/} | Average depth of stream in ft. ^{3/} | Range in gradient ^{3/} | Range in velocity in ft./sec. ^{3/} | Temperatures in degrees F. | Date | Productive potential | Possible limiting factors | Type of control possible ^{4/} |
|------------------------------|--|---|--|--|---------------------------------|---|----------------------------|--------|----------------------|-------------------------------------|--|
| Kelsey Creek | Baraga, 52-23-27 | 10.25 | 8.0 | 0.25 | Slight | 1.0 | 56 | 9/6/50 | Small | Spawning sites, obstacles, velocity | Mechanical weir & trap |

^{1/} List includes only those streams which appear to have a productive potential or for which control devices have been recommended.

^{2/} "Length" is the measurement of that portion of the stream surveyed, and is composed of a calculation of map distance plus application of a corrective factor (variable) compiled from field measurements. The stream length figures differ from total length in all cases where field conditions terminated the area usable by sea lampreys short of the headwaters.

^{3/} Applicable only to the surveyed portion of the stream.

^{4/} From an engineering standpoint, electrical control devices can probably be installed in all streams for which mechanical devices have been recommended.

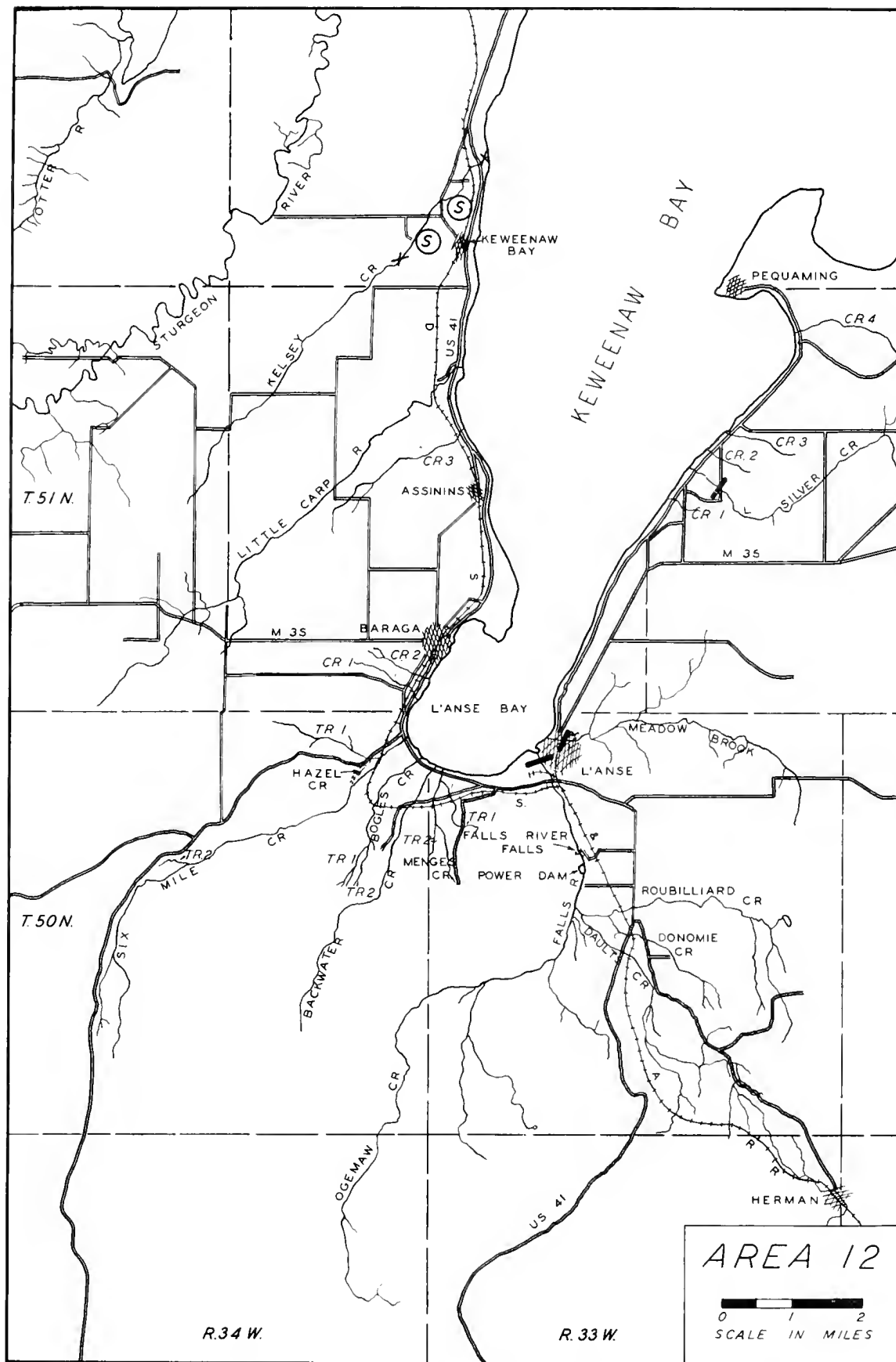


Figure 13.--Area 12.

Description of Area 12 (Fig. 13)

Embraces a portion of north and northwestern Baraga County, Mich., and contains the watersheds of the Falls and Little Carp Rivers, Little Silver, Backwater, Six Mile, and Kelsey Creeks, and a number of small coastal streams. Only Kelsey Creek has a productive potential; a mechanical control device is recommended. This stream is brown in color, has a slight gradient and low water velocity, and contains only a trace of spawning materials. The area is made up of level or slightly rolling, wet sand plain on the old glacial lake shores. Drainages are poorly defined, and bogs and swamps are common. Soils are light; alder-popple scrub and bog conifers characterize the area.

Table 13.--Productive potential, recommended control devices,
and miscellaneous factors concerning streams in Area 13
(Survey made in 1950)

| Name of stream ^{1/} | County, township line, range, and section no. at mouth | Length of stream in miles ^{2/} | Average width of stream in ft. ^{3/} | Average depth of stream in ft. ^{3/} | Range in gradient ^{3/} in ft. ^{3/} | Range in velocity in ft./sec. ^{3/} | Tempa- tures in degrees F. | Date | Productive potential | Possible limiting factors | Type of control possible ^{4/} |
|------------------------------|--|---|---|---|--|---|----------------------------------|------|-------------------------|--|--|
| Sturgeon River | Houghton, 54-33-33 | 80.0 | 76.0 | 2.6 | Slight-moderate | Sluggish-1.5 | 60-62 | 8/29 | None | Spawning materials, level fluct., obstacles | Electrical |
| W. Br. Sturgeon River | Beraga, 51-34-16 | 26.0 | 27.5 | 0.66 | Slight-moderate | 1.75- ? | 58 | 9/10 | Large | Level fluct., obstacles | Electrical |
| Otter River | Houghton, 52-34-14 | 32.0 | 35.0 | 0.75 | Slight-steep | 1.0 -2.25 | 52 | 9/14 | Large | Temperature obstacles, level fluct., obstacles | 5/ |
| N. Br. Otter River | Houghton, 51-35-1 | 26.0 | 22.0 | 1.0 | Slight-moderate | 1.5-1.75 | 50-54 | 9/9 | Large | Level fluct., obstacles, temperature | 5/ |
| Bear Creek | Houghton, 52-33-25 | 1.75 | 12.0 | 0.5 | Slight | Sluggish-1.25 | --- | --- | Small | Obstacles, velocity, spawning materials | 5/ |
| Sante River | Houghton, 53-34-32 | 8.0 | 14.5 | 0.5 | Slight | 0.75-1.5 | --- | --- | Medium | Obstacles, temperature | 5/ |
| Thirteen Creek | Houghton, 53-35-35 | 1.0 | 10.0 | 0.5 | Slight | Sluggish-1.0 | --- | --- | Small | Spawning sites, velocity, obstacles, temperature | 5/ |
| Bruno Creek | Houghton, 51-35-16 | 2.25 | 15.0 | 0.5 | Moderate-steep | 1.5-1.75 | --- | --- | Small | Obstacles, temperature | 5/ |
| Lake Fifteen Cr. | Houghton, 51-35-19 | 0.5 | 6.0 | 0.5 | Moderate-steep | 1.75 | --- | --- | Small | Spawning sites, temperature | 5/ |
| Pike River | Houghton, 53-33-5 | 8.0 | 18.0 | 1.0 | Slight-moderate | 1.0-1.5 | 52-54 | 9/3 | Medium | Temperature level fluct., velocity, temperature | Mechanical weir & trap |

^{1/} List includes only those streams which appear to have a productive potential or for which control devices have been recommended.

^{2/} "Length" is the measurement of that portion of the stream surveyed, and is composed of a calculation of map distance plus application of a corrective factor (variable) compiled from field measurements. The stream length figures differ from total length in all cases where field conditions terminated the area usable by sea lampreys short of the headwaters.

^{3/} Applicable only to the surveyed portion of the stream.

^{4/} From an engineering standpoint, electrical control devices can probably be installed in all streams for which mechanical devices have been recommended.

^{5/} Stream tributary to another upon which it would be more practical to place a control device.

Description of Area 13 (Fig. 14)

Embraces central Houghton County and portions of western Baraga and eastern Ontonagon Counties, Michigan, and contains the Sturgeon, Snake, and Pike River watersheds, and several small coastal streams. The tremendous Sturgeon system and the Pike watershed both contain abundant spawning facilities. An electrical device is recommended for the Sturgeon; a mechanical structure is suitable for the Pike. The streams of the area are generally brown in color and gradients are slight to steep. Hard-bottom materials are common, but soft components also occur frequently. Much of the area lies in the old lake clays region; the topography varies from wet bottoms to rolling hills. Forest and agricultural lands occur equally.

Table 14.--Productive potential, recommended control devices,
and miscellaneous factors concerning streams in Area 14
(Survey made in 1950)

| Name of stream ^{1/} | Length of stream in miles ^{2/} | Average width of stream in ft. ^{3/} | Average depth of stream in ft. ^{3/} | Range in velocity in ft./sec. ^{3/} | Range in gradient ^{3/} | Temperature in degrees F. | Productive potential | Possible limiting factors | Type of control possible ^{4/} |
|------------------------------|---|--|--|---|---------------------------------|---------------------------|----------------------|---|--|
| Pilgrim River | 15.25 | 21.5 | 0.66 | Slight-moderate | 1.25-1.5 | 45-55 | Large | Temperature, obstacles, level fluctuations, level fluctuations, pollution, distance | Mechanical weir & trap |
| Trap Rock River | 12.0 | 27.5 | 1.26 | Moderate | 1.0-1.5 | 56-65 | Medium | Level fluctuations, pollution, distance | Electrical |
| Hammell Creek | 3.25 | 6.0 | 0.5 | Slight-steep | 0.75-2.0 | 63-64 | Small | Spawning sites, velocity, pollution | ^{5/} |
| Sawmill Creek | 6.0 | 6.0 | 1.5 | Slight-steep | 1.5-2.0 | 64-65 | Medium | Obstacles, level fluct., temperature | Mechanical weir & trap |
| McCollum Creek | 6.0 | 6.5 | 0.5 | Slight-moderate | 1.5-2.25 | 54 | Medium | Obstacles, level fluct., temperature | Mechanical weir & trap |
| Lauti Creek | 2.25 | 12.0 | 1.0 | Slight | Sluggish-0.5 | 57 | Small | Spawning sites, velocity | Mechanical weir & trap |

- ^{1/} List includes only those streams which appear to have a productive potential or for which control devices have been recommended.
- ^{2/} "Length" is the measurement of that portion of the stream surveyed, and is composed of a calculation of map distance plus application of a corrective factor (variable) compiled from field measurements. The stream length figures differ from total length in all cases where field conditions terminated the area usable by see lamprays short of the headwaters.
- ^{3/} Applicable only to the surveyed portion of the stream.
- ^{4/} From an engineering standpoint, electrical control devices can probably be installed in all streams for which mechanical devices have been recommended.
- ^{5/} Stream tributary to another upon which it would be more practical to place a control device.

Description of Area 14 (Fig. 15)

Embraces most of the northern half of Houghton and a small portion of Keweenaw County, Mich., and contains the watersheds of the Pilgrim and Trap Rock Rivers, Hammell, Lahti, Gooseneck, Sawmill, and McCallum Creeks, and a large number of small coastal streams tributary to either Lake Superior or the Portage Waterway. Appreciable productive potentials occur in all but Lahti and Gooseneck Creeks. Mechanical control devices are recommended for all the potential producers but the Trap Rock; an electrical device will be necessary in that stream. The streams of the area are generally brown in color and clear (except for some transient turbidity in the Trap Rock due to pollution). Gradients range from slight to steep. Hard-bottom materials are plentiful. The topography is broken, and drainages are well defined. Agricultural lands predominate in the valleys, but much forested upland and timbered bog are present.

Table 15.--Productive potential, recommended control devices,
and miscellaneous factors concerning streams in Area 15
(Survey made in 1950)

| Name of stream ^{1/} | County, township line, range, and section no. at mouth | Length of stream in miles ^{2/} | Average width of stream in ft. ^{3/} | Average depth of stream in ft. ^{3/} | Range in gradient ^{3/} | Range in velocity in ft./sec. ^{3/} | Tempera- tures in degrees F. ^{3/} | Date | Productive potential | Possible limiting factors | Type of control possible ^{4/} |
|------------------------------|--|---|---|---|------------------------------------|---|--|-------------|-------------------------|---|--|
| Traverse River | Houghton, 55-31-4 | 11.5 | 13.5 | 1.0 | Slight | 1.0-2.25 | 55-57 | 8/14, 16/50 | Medium | Spawning sites, fluctuations, obstacles | Electrical |
| Tobacco River | Keweenaw, 56-30-20 | 22.0 | 13.5 | 1.0 | Slight-moderate | 0.5-3.5 | 66-68 | 8/10 | Medium | Spawning sites, fluctuations, obstacles | Electrical |
| Big Betsy River | Keweenaw, 57-30-36 | 3.5 | 7.5 | 1.0 | Slight | Sluggish-0.75 | 62-64 | 8/9 | Small | Velocity, obstacles | Mechanical |
| Little Betsy River | Keweenaw, 57-29-29 | 1.75 | 6.0 | 0.75 | Slight-moderate | 0.5-2.5 | --- | --- | Small | Spawning sites, fluctuations, obstacles, temperature | weir & trap Mechanical |

^{1/} List includes only those streams which appear to have a productive potential or for which control devices have been recommended.

^{2/} "Length" is the measurement of that portion of the stream surveyed, and is composed of a calculation of map distance plus application of a corrective factor (variable) compiled from field measurements. The stream length figures differ from total length in all cases where field conditions terminated the area usable by sea lampreys short of the headwaters.

^{3/} Applicable only to the surveyed portion of the stream.

^{4/} From an engineering standpoint, electrical control devices can probably be installed in all streams for which mechanical devices have been recommended.

^{5/} Stream tributary to another upon which it would be more practical to place control device.

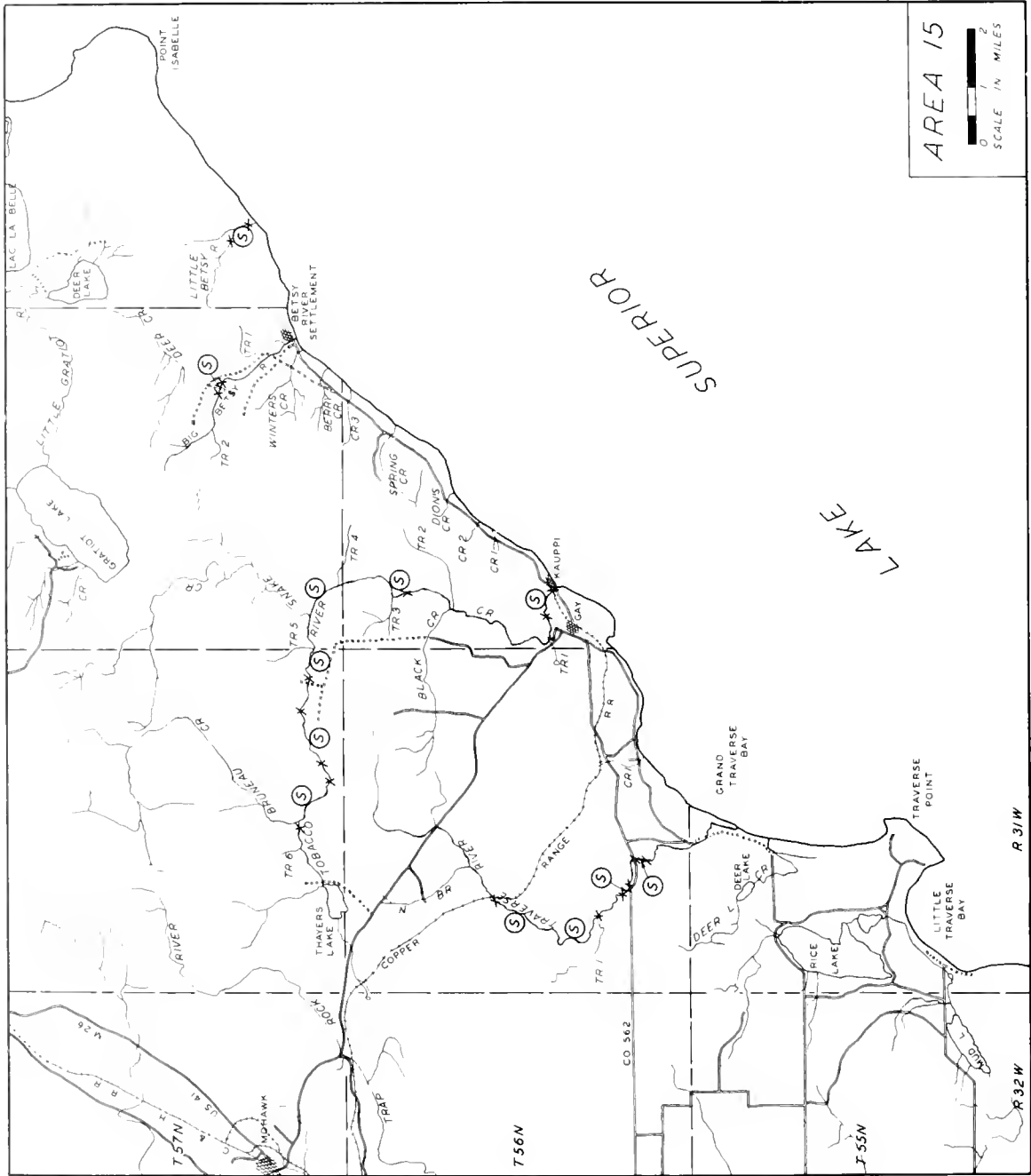


Figure 16.—Area 15.

Description of Area 15 (Fig. 16)

Embraces the southeastern portion of Keweenaw County, Mich., and contains the watersheds of the Traverse, Tobacco, Big Betsy, and Little Betsy Rivers, and several small coastal streams. All of the named streams are potential sea lamprey producers, but only the Traverse and Tobacco are significantly dangerous. A questionable record of five "probable" nests exists for the Traverse. Electrical control devices are recommended for both the Traverse and Tobacco Rivers; electrical devices will also be more suitable in the Betsy Rivers if power lines are made available. The streams in the area are generally brown in color and gradients range from slight to steep. Hard-bottom materials are abundant. The topography ranges from low, sandy plains and bogs in the lower watersheds to rugged, rocky, upland wilderness; glaciated soils and land features characterize the area. Ecological situations are equally varied and complex.

Table 16.--Productive potential, recommended control devices,
and miscellaneous factors concerning streams in Area 16
(Survey made in 1950)

| Name of stream ^{1/} | County, township line, range, and section no. at mouth | Length of stream in miles ^{2/} | Average width of stream in ft. ^{2/} | Average depth of stream in ft. ^{2/} | Range in gradient ^{3/} in ft. ^{2/} per 100 ft. ^{2/} | Range in velocity in ft./sec. ^{3/} | Temper- atures in degrees F. | Date | Productive potential | Possible limiting factors | Type of control possible ^{4/} |
|------------------------------|--|---|---|---|---|---|------------------------------------|---------------|-------------------------|--|--|
| Little Gnatnot River | Keweenaw, 58-29-31 | 8.5 | 14.0 | 1.75 | Moderate | 1.5-2.0 | 66-70 | 7/30 | Large | Fluctuations, obstacles, isolated spawning sites, velocity, obstacles | Electrical |
| Elester Creek | Keweenaw, 57-30-4 | 5.0 | 3.0 | 0.5 | Slight-steep | Sluggish-1.5 | 53 | 8/2 | Small | Velocity, obstacles | 5/ |
| Nine Thirty Two Creek | Keweenaw, 57-30-8 | 1.5 | 3.0 | 0.5 | Slight-steep | 7-1.0 | --- | --- | Small | Temperature spawning sites, fluct., velocity, obstacles | 5/ |
| Bear Creek | Keweenaw, 58-28-30 | 2.0 | 5.5 | 0.66 | Moderate-steep | Sluggish-1.0 | 51-53 | 7/24 & 8/3 | Small | Temperature spawning sites, fluct., velocity, obstacles | Mechanical weir & trap |
| Hear Creek | Keweenaw, 58-28-25 | 2.0 | 4.0 | 0.75 | Slight | 0.5 | 60 | 7/27 | Small | Spawning sites, obstacles | Mechanical weir & trap |
| Union Creek | Keweenaw, 58-27-21 | 4.5 | 5.0 | 0.5 | Slight-moderate | 0.5-1.5 | 62 | 7/27 | Small | Obstacles | Mechanical weir & trap |

^{1/} List includes only those streams which appear to have a productive potential or for which control devices have been recommended.

^{2/} "Length" is the measurement of that portion of the stream surveyed, and is composed of a calculation of map distance plus application of a corrective factor (variable) compiled from field measurements. The stream length figures differ from total length in all cases where field conditions terminated the area usable by sea lampreys short of the headwaters.

^{3/} Applicable only to the surveyed portion of the stream.

^{4/} From an engineering standpoint, electrical control devices can probably be installed in all streams for which mechanical devices have been recommended.

^{5/} Stream tributary to another upon which it would be more practical to place a control device.

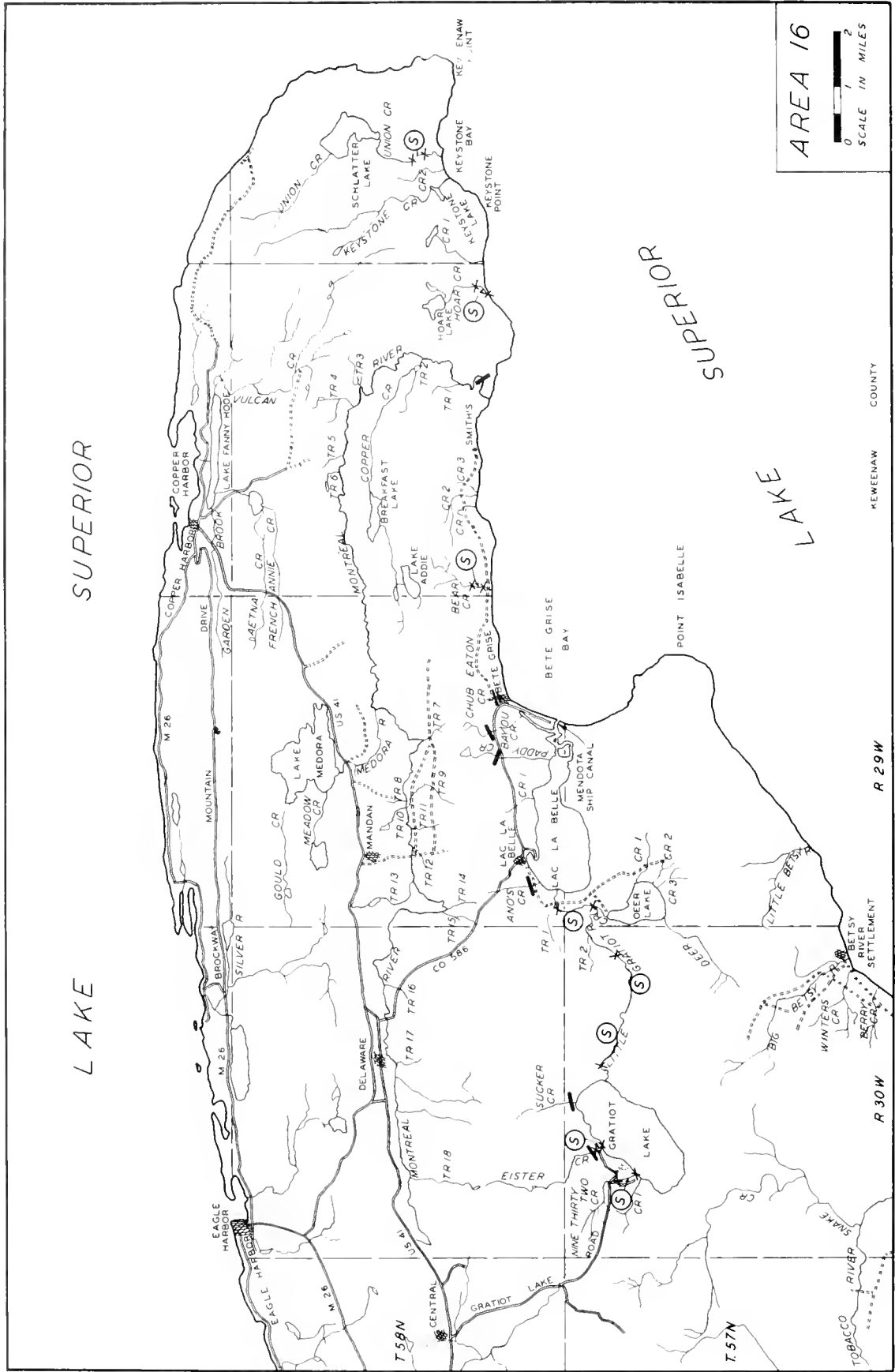


Figure 17.---Area 16.

Description of Area 16 (Fig. 17)

Embraces most of the southeastern portion of Keweenaw County, Mich., and contains the watersheds of the Little Gratiot River-Mendota system, the Montreal River, Bear, Hoar, and Union Creeks, and a number of small coastal streams; all but the Montreal have a productive potential; only the Little Gratiot is considered dangerous. An electrical installation is recommended for the Little Gratiot; mechanical devices will be suitable in the other streams. The streams in the area are uniformly brown in color and gradients range from slight to steep. Hard-bottom types are abundant only in the Little Gratiot. Characteristically the area is rugged, rocky, mountainous upland, but a narrow band of low, swampy, sand plain borders the lakeshore; soils are generally light and thin. Coniferous stands in the lowlands and mixed hardwoods on the slopes form the forest cover.

Table 17.--Potential nest sites, productive potential, recommended control devices,
and miscellaneous factors concerning streams in Area 17
(Survey made in 1951)

| Name of stream ^{1/} | County, township line, range, and section no. at mouth | Length of stream in miles | Average width of stream in ft. ^{2/} | Average depth of stream in ft. ^{3/} | Range in gradient ^{4/} in ft. ^{3/} | Range in velocity in ft./sec. ^{5/} | Temperature in degrees F. | Date | Number of potential nest sites observed | Productive potential | Possible limiting factors | Type of control possible ^{4/} |
|------------------------------|--|---------------------------|--|--|--|---|---------------------------|------|---|----------------------|---|--|
| Lake Penny Hooe Creek | Keweenaw, 56-28-33 | 0.5 | 25.0 | 1.0 | Moderate | 1.5 | 62 | 7/24 | None | 0 | --- | Barrier dam |
| Mud Lake Creek | Keweenaw, 59-28-34 | 0.5 | 15.0 | 0.75 | Slight | Sluggish | --- | --- | 12 | Medium | Temperature | ^{5/} |
| Vulcan Creek | Keweenaw, 59-28-34 | 9.0 | 8.0 | 0.25 | Moderate | 1.0 | 61 | 7/23 | 25 | Medium | Irregular bottom | ^{5/} |
| Garden Brook | Keweenaw, 59-28-32 | 5.5 | 8.0 | 0.2 | Slight-moderate | 0-1.0 | --- | --- | 40 | Medium | Temperature, velocity | ^{5/} |
| Glazen Creek | Keweenaw, 59-29-31 | 0.75 | 3.0 | 0.2 | Slight | 0-1.0 | --- | --- | 3 | Small | Temperature | Mechanical weir & trap |
| Silver River | Keweenaw, 59-30-35 | 7.0 | 20.0 | 1.0 | Slight-steep | Sluggish-1.0 | 57 | 7/24 | 100 | Large | Temperature | Barrier dam |
| Little Silver River | Keweenaw, 59-30-35 | 1.0 | 3.0 | 0.2 | Slight-steep | 0.5-1.0 | 58 | 7/24 | --- | Medium | Temperature, irregular bottom | ^{5/} |
| Cedar Creek | Keweenaw, 59-30-5 | 5.0 | 6.0 | 0.5 | Slight-steep | 0.5 | 56 | 7/24 | 40 | Medium | Temperature, velocity, irregular bottom | Electrical |
| Elizo Lake Creek | Keweenaw, 59-30-6 | 1.0 | 15.0 | 0.5 | Slight-steep | 0.5 | 64 | 7/24 | 80 | Large | Velocity | Mechanical weir & trap |

^{1/} List includes only those streams which appear to have a productive potential or for which control devices have been recommended.

^{2/} "Length" is recorded as twice the calculated map distance (the map distance is usually at least doubled by the actual meanders of the stream).

^{3/} Applicable only to the surveyed portion of the stream.

^{4/} From an engineering standpoint, electrical control devices can probably be installed in all streams for which mechanical weirs and traps or barrier dams have been recommended.

^{5/} Stream tributary to another upon which it would be more practical to place a control device.

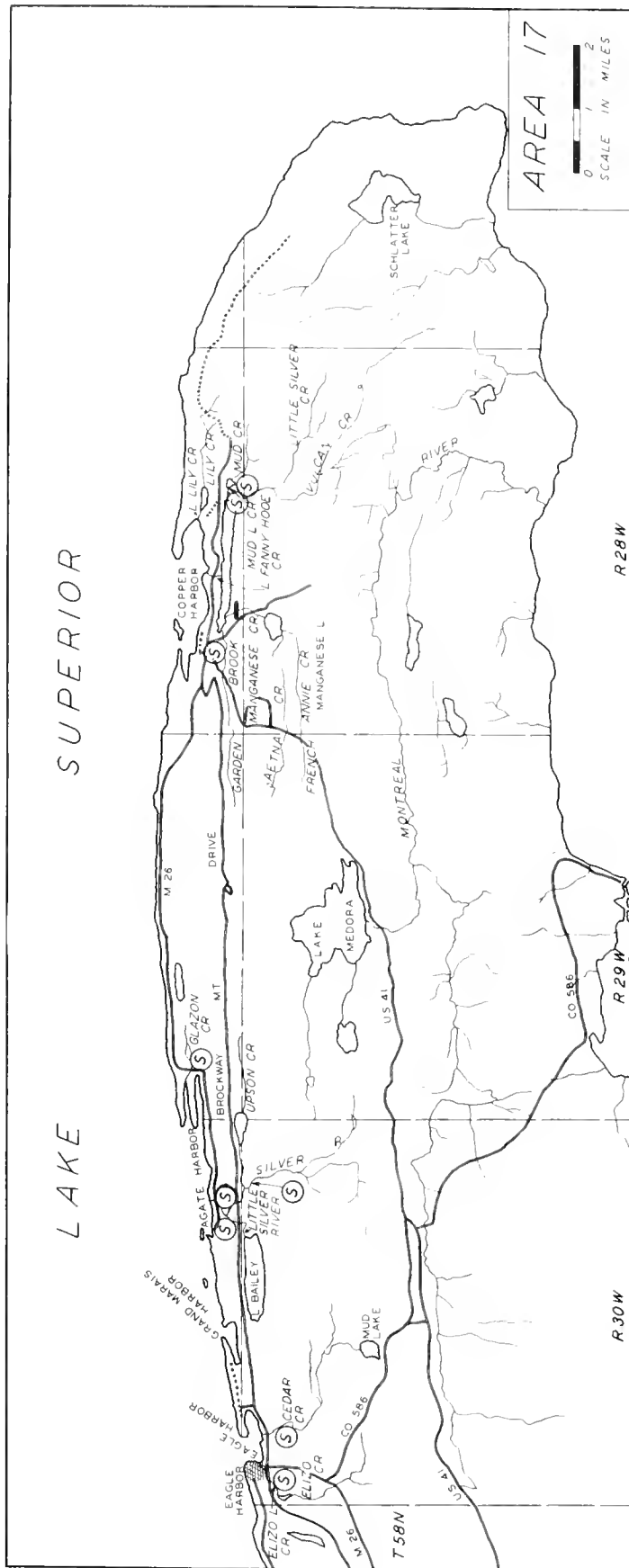


Figure 18.---Area 17.

Description of Area 17 (Fig. 18)

Embraces the northeast portion of Keweenaw County, Mich., and contains six small river systems. Some type of control may be required in five of them. The Silver River, Elizo Creek, and the Lake Fanny Hooe Creek systems appear to be capable of producing large numbers of sea lampreys; Glazon and Cedar Creeks have facilities for fewer nests. The Silver River and Lake Fanny Hooe Creek systems may be controlled by concrete barrier dams which can be constructed on bedrock substrata. Sites for mechanical weirs are present close to the mouths of Elizo Lake and Glazon Creeks, but an electrical control device will probably be necessary in Cedar Creek because of the low banks. All of the control sites are readily accessible. Stream gradients are generally steep, and water velocities are high in some stream sections. The stream bottoms are largely hard and irregular. Low water temperatures and sudden freshets may limit the amount of spawning and the freshets may interfere with control operations.

Table 18.--Potential nest sites, productive potential, recommended control devices, and miscellaneous factors concerning streams in Area 18
(Survey made in 1951)

| Name of stream ^{1/} | County, township line, range, and section no. at mouth | Length of stream in miles ^{2/} | Average width of stream in ft. ^{3/} | Average depth of stream in ft. ^{3/} | Range in gradient ^{3/} | Range in velocity in ft./sec. ^{3/} | Temperature in degree F. | Date | Number of potential nest sites observed ^{3/} | Productive potential | Possible limiting factors | Type of control possible ^{4/} |
|------------------------------|--|---|--|--|---------------------------------|---|--------------------------|------|---|----------------------|---------------------------|--|
| Garden City Brook | Keweenaw, 58-31-19 | 4.0 | 10.0 | 0.3 | Moderate-steep | 1.0 | 63 | 7/25 | 40 | Medium | None | Mechanical weir & trap |
| Morrison Creek | Keweenaw, 58-32-26 | 7.0 | 20.0 | 0.2 | Slight-steep | Sluggish | 61 | 7/27 | 50 | Medium | None | Electrical |
| Grotiot River | Keweenaw, 57-33-11 | 25.0 | 40.0 | 0.5 | Slight-steep | 0.5 | 60 | 7/28 | 200 + | Large | None | Electrical |
| Hall Creek | Keweenaw, 57-33-14 | 16.0 | 15.0 | 0.5 | Slight-moderate | 1.0 | 56 | 7/31 | 100 + | Large | Temperature | Electrical |
| Black Creek | Keweenaw, 57-33-14 | 14.0 | 10.0 | 0.75 | Slight-steep | 0.0-Sluggish | 62 | 7/31 | 25 | Medium | Drying | ^{5/} |

^{1/} List includes only those streams which appear to have a productive potential or for which control devices have been recommended.

^{2/} "Length" is recorded as twice the calculated map distance (the map distance is usually at least doubled by the actual meanders of the stream).

^{3/} Applicable only to the surveyed portion of the stream.

^{4/} From an engineering standpoint, electrical control devices can probably be installed in all streams for which mechanical devices have been recommended.

^{5/} Stream tributary to another upon which it would be more practical to place a control device.

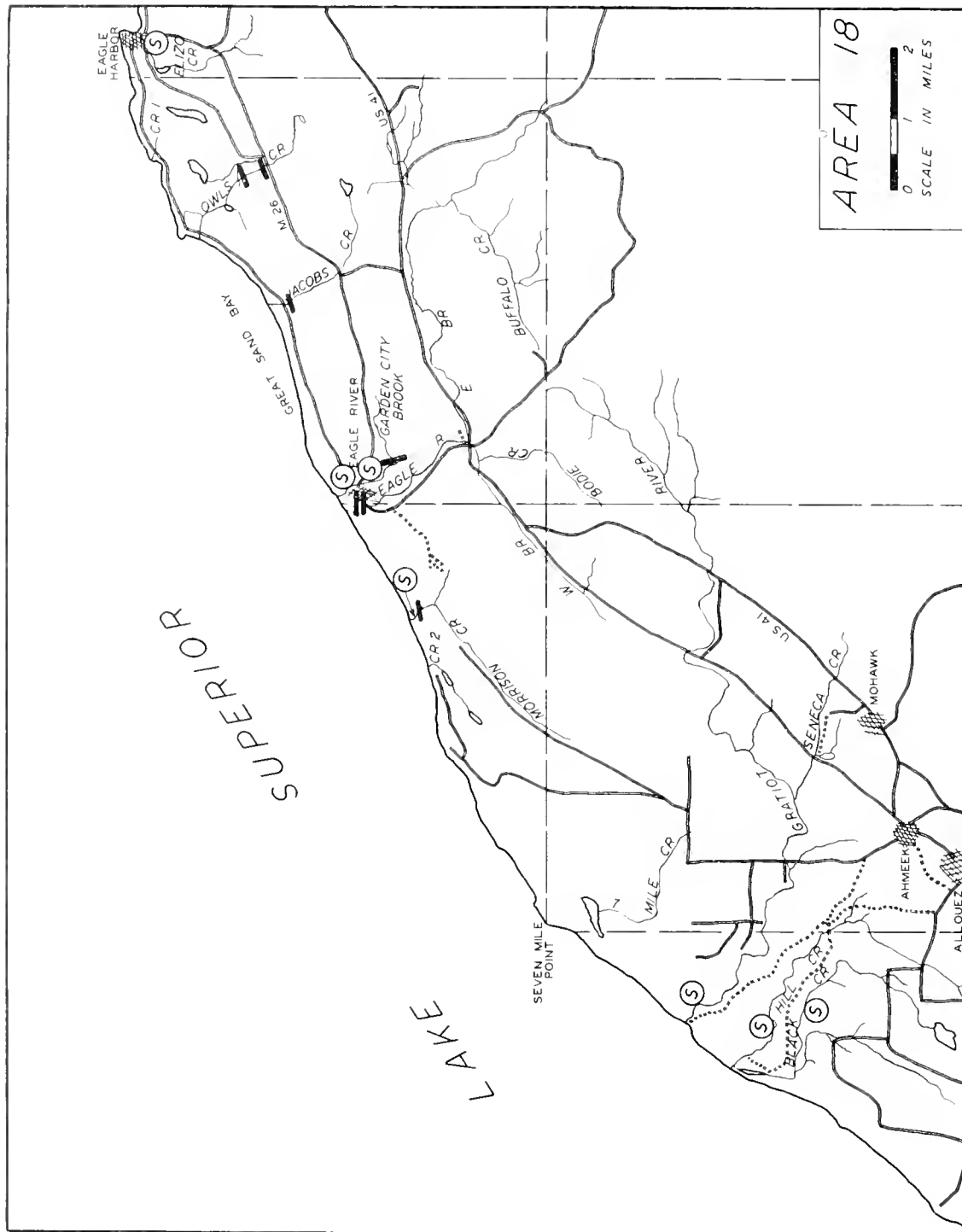


Figure 19. Area 18.

Description of Area 18 (Fig. 19)

Embraces the northwest portion of Keweenaw County, Mich., and contains nine small river systems. Abundant spawning facilities are available in the Gratiot River and in the Hill Creek system; sites for fewer nests (40-50) are present in both Garden City Brook and Morrison Creek. A mechanical weir can be constructed close to the mouth of Garden City Brook. Electrical devices will be more practical in the other streams; good sites for mechanical weirs are lacking. Morrison Creek is relatively inaccessible. The stream gradients are generally steep, and velocities are high during the spring. The surrounding country is sandy and rugged. Hardwoods are predominant.

Table 19.--Potential nest sites, productive potential, recommended control devices,
and miscellaneous factors concerning streams in Area 19
(Survey made in 1951)

| Name of stream | Length of stream in miles | Average width of stream in ft. | Average depth of stream in ft. | Range in gradient 3/ | Range in velocity in ft./sec. 3/ | Temperature in degrees F. | Number of potential nest sites observed 3/ | Productive potential | Possible limiting factors | Type of control, possible 4/ |
|---------------------|---------------------------|--------------------------------|--------------------------------|----------------------|----------------------------------|---------------------------|--|----------------------|---|------------------------------|
| Streamy Creek | 7.0 | 3.0 | 1.5 | Moderate | 0.5 | 62 | 4 | Small | Small size, irregular bottom | Mechanical weir & trap |
| Gardner's Creek | 3.5 | 4.0 | 0.25 | Slight-steep | 1.0-3.0 | 63 | 4 | Small | Irregular bottom | Mechanical weir & trap |
| Creek # 1 | 1.0 | 6.0 | 0.25 | Moderate-steep | 1.5 | 56 | 30 | Medium | Temperature, velocity | Mechanical weir & trap |
| Creek # 2 | 3.0 | 4.0 | 0.25 | Moderate-steep | 1.5 | 67 | 30 | Medium | Velocity | Mechanical weir & trap |
| Creek # 3 | 2.0 | 2.0 | 0.25 | Moderate-steep | 1.5 | 60 | 6 | Medium | Velocity | Mechanical weir & trap |
| McGunn's Creek | 6.5 | 20.0 | 0.3 | Moderate-steep | 2.0 | 66 | 12 | Medium | Irregular bottom | Mechanical weir & trap |
| Smith Creek | 5.0 | 3.0 | 0.3 | Steep | 1.0-2.0 | 66 | 3 | Small | Irregular bottom | Mechanical weir & trap |
| Creek # 5 | 2.5 | 3.0 | 0.1 | Moderate-steep | 0.0-slugish | 61 | 4 | Small | Irregular bottom, small size | Mechanical weir & trap |
| Bear Creek | 6.0 | 17.0 | 2.0 | Slight-moderate | 1.0 | 56 | 25 | Medium | Temperature | Mechanical weir & trap |
| Boston Creek | 8.0 | 25.0 | 0.5 | Slight-steep | 1.5 | 57 | 100 | Large | Temperature | Electrical |
| Lily Creek | 10.0 | 30.0 | 0.5 | Slight-steep | 1.0 | 61 | 300 | Large | None | 5/ |
| Creek # 1 | 2.5 | 3.0 | 0.3 | Steep | 1.0 | 64 | 4 | Small | Small size, velocity, irregular bottom | Mechanical weir & trap |
| Creek # 2 | 3.0 | 5.0 | 0.2 | Steep | 1.0 | 56 | 8 | Medium | Temperature, irregular bottom | Mechanical weir & trap |
| Creek # 4 | 1.0 | 8.0 | 0.1 | Steep | 0.75 | 55 | 3 | Small | Temperature, velocity, irregular bottom | Mechanical weir & trap |
| Swede Torn Creek | 6.0 | 18.0 | 0.25 | Moderate-steep | 1.0 | 61 | 65 | Medium | Temperature, velocity, irregular bottom | Mechanical weir & trap |
| Creek # 1 | 5.0 | 20.0 | 0.1 | Slight-steep | 0.75 | 70 | 4 | Small | Irregular bottom, drying | Mechanical weir & trap |
| Coles Creek | 8.0 | 25.0 | 0.5 | Steep | 3.0 | 54 | 4 | Small | Temperature, velocity, irregular bottom | Electrical |
| Schlottz Creek | 8.0 | 15.0 | 0.5 | Slight-moderate | 1.0 | 56 | 100 | Large | Temperature | Mechanical weir & trap |
| Salmon Trout River | 22.0 | 40.0 | 0.25 | Moderate | Sluggish-1.0 | 62 | 12 | Medium | None | Electrical |
| Graveset River | 17.0 | 25.0 | 1.0 | Slight-steep | 1.5 | 54 | 100 | Large | None | Barrier dam |
| Elm River | 26.0 | 30.0 | 0.4 | Moderate-steep | 1.5-2.0 | 59 | 50 | Medium | Temperature, velocity, irregular bottom | Electrical |
| South Branch Elm R. | 8.0 | 20.0 | 0.8 | Slight-steep | 1.0 | 59 | 100 | Large | Temperature, velocity | 5/ |
| Little Elm River | 14.0 | 35.0 | 1.0 | Slight-steep | 0.0-1.5 | 60 | 50 | Medium | Temperature, velocity | Electrical |

1/ list includes only those streams which appear to have a productive potential or for which control devices have been recommended.

2/ "Length" is recorded as twice the calculated map distance (the map distance is usually at least doubled by the actual meanders of the stream).

3/ applicable only to the surveyed portion of the stream.

4/ from an engineering standpoint, electrical control devices can probably be installed in all streams for which mechanical weirs and traps or barrier dams have been recommended.

5/ Stream tributary to another upon which it would be more practical to place a control device.

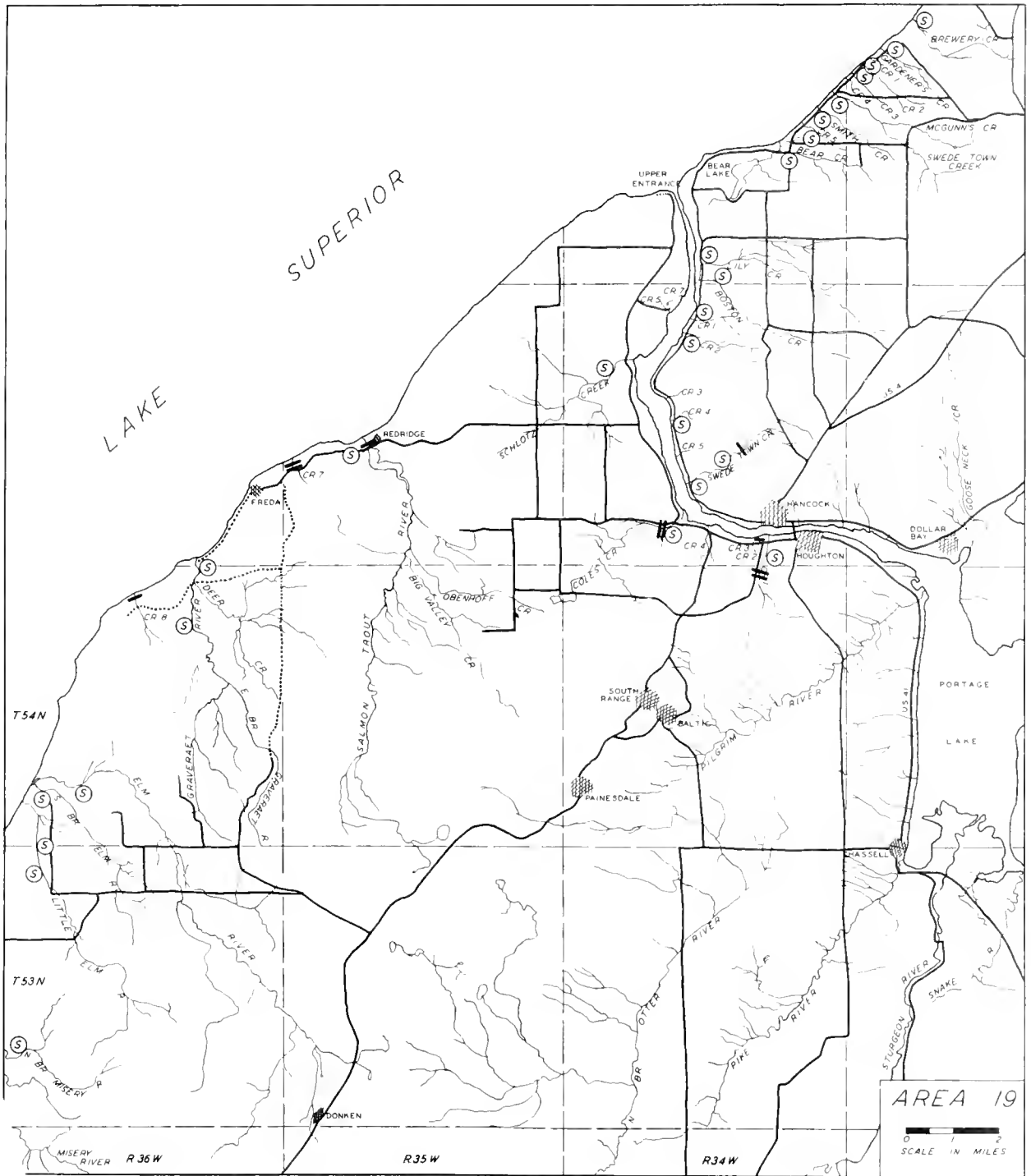


Figure 20.--Area 19.

Description of Area 19 (Fig. 20)

Embraces the entire northern coastline of Houghton County, Mich., and the northern portion of the Portage Waterway. Spawning facilities are available in 21 river systems, 8 of which flow into the Portage Waterway. Abundant facilities are present in four watersheds: Boston and Schlotz Creeks, tributary to the canal, and the Graveraet and Elm Rivers in the western portion of the area. Ten other watersheds each offer facilities for from 6 to 65 nests. Sites for less than 5 nests are present in each of the remaining streams listed (table 19). Sites for mechanical weirs are present near the mouths of 15 streams. Electrical control devices are recommended for the Salmon Trout, Elm, and Little Elm Rivers, which are too large for practical mechanical structures, and for Boston and Coles Creeks in which sites for mechanical weirs are lacking. A concrete barrier dam is recommended for the Graveraet River. The Graveraet and Elm Rivers are relatively inaccessible. Stream gradients are generally steep, and velocities are high. Low water temperatures and freshets may inhibit spawning. The large water volumes present in the spring and during periods of heavy rain may interfere with control operations. The country east of the Portage Waterway is generally sandy while morainic formations and lake clays are predominant to the west. The entire area is rugged. The forest climax type is largely hardwood.

Table 20.--Potential nest sites, productive potential, recommended control devices,
and miscellaneous factors concerning streams in Area 20
(Survey made in 1951)

| Name of stream ^{1/} | County, township line, range, and section no. at mouth | Length of stream in miles ^{2/} | Average width of stream in ft. ^{3/} | Average depth of stream in ft. ^{3/} | Range in gradient ^{3/} in ft. ^{3/} | Range in velocity in ft./sec. ^{3/} | Temperature in degrees F. | Date | Number of potential nest sites observed ^{3/} | Productive potential | Possible limiting factors | Type of control possible ^{4/} |
|------------------------------|--|---|---|---|--|---|---------------------------------|------|--|-------------------------|------------------------------------|---|
| Asbury River | Ontonagon, 58-39-10 | 30.0 | 45.0 | 2.0 | Slight-moderate | 0.0-2.0 | 54 | 8/11 | 80 | Large | Temperature | Electrical |
| East Sleeping River | Ontonagon, 53-39-13 | 30.0 | 60.0 | 0.5 | Slight-steep | Sluggish-1.0 | 60 | 8/25 | 200 ⁺ | Large | None | Electrical |
| West Sleeping River | Ontonagon, 58-39-13 | 11.0 | 10.0 | 0.3 | Slight-moderate | Sluggish-1.5 | 59 | 8/24 | 100 ⁺ | Large | Temperature | Electrical |
| Firesteel River | Ontonagon, 58-39-1 | 75.0 | 40.0 | 1.0 | Slight-steep | Sluggish-2.0 | 72 | 8/27 | 1000 ⁺ | Large | None | Electrical |
| Flintsteel River | Ontonagon, 58-39-2 | 33.0 | 100.0 | 6.0 | Slight | Sluggish-0.75 | 73 | 8/27 | 100 ⁺ | Large | None | Electrical |
| Bear Creek | Ontonagon, 52-39-15 | 16.0 | 20.0 | 0.5 | Slight-moderate | Sluggish-1.0 | --- | --- | 4 | Small | Temperature | Mechanical weir & trap |
| Ontonagon River | Ontonagon, 52-40-25 | 100 ⁺ | 100.0 | 2.0 | Slight-steep | Sluggish-5.0 | 59 | 8/23 | 200 ⁺ | Large | None | Electrical |
| First Creek | Ontonagon, 52-40-34 | 14.0 | 10.0 | 0.5 | Slight-moderate | Sluggish | 60 | 8/22 | 4 | Small | Spawning materials | Mechanical weir & trap |
| Second Creek | Ontonagon, 52-40-34 | 14.0 | 12.0 | 0.5 | Slight | Sluggish-1.0 | 58 | 8/25 | 4 | Small | Temperature, spawning materials | Mechanical weir & trap |
| Potato River | Ontonagon, 52-40-33 | 30.0 | 35.0 | 2.0 | Slight-moderate | Sluggish-1.0 | 58 | 8/22 | 100 ⁺ | Large | Temperature | Electrical |
| Floodwood River | Ontonagon, 51-40-4 | 17.0 | 20.0 | 0.5 | Slight-moderate | Sluggish | 58 | 8/25 | 75 | Large | Temperature, velocity | Electrical |
| Cranberry River | Ontonagon, 51-40-6 | 25.0 | 40.0 | 0.6 | Slight-moderate | Sluggish | 64 | 8/27 | 100 ⁺ | Large | None | Electrical |
| Little Cranberry R. | Ontonagon, 51-40-6 | 16.0 | 30.0 | 1.0 | Moderate | Sluggish | 63 | 8/29 | 100 ⁺ | Large | None | Electrical |

^{1/} List includes only those streams which appear to have a productive potential or for which control devices have been recommended.

^{2/} "Length" is recorded as twice the calculated map distance (the map distance is usually at least doubled by the actual meanders of the stream).

^{3/} Applicable only to the surveyed portion of the stream.

^{4/} From an engineering standpoint, electrical control devices probably can be installed in all streams for which mechanical weirs and traps have been recommended.

^{5/} Stream tributary to another upon which it would be more practical to place a control device.

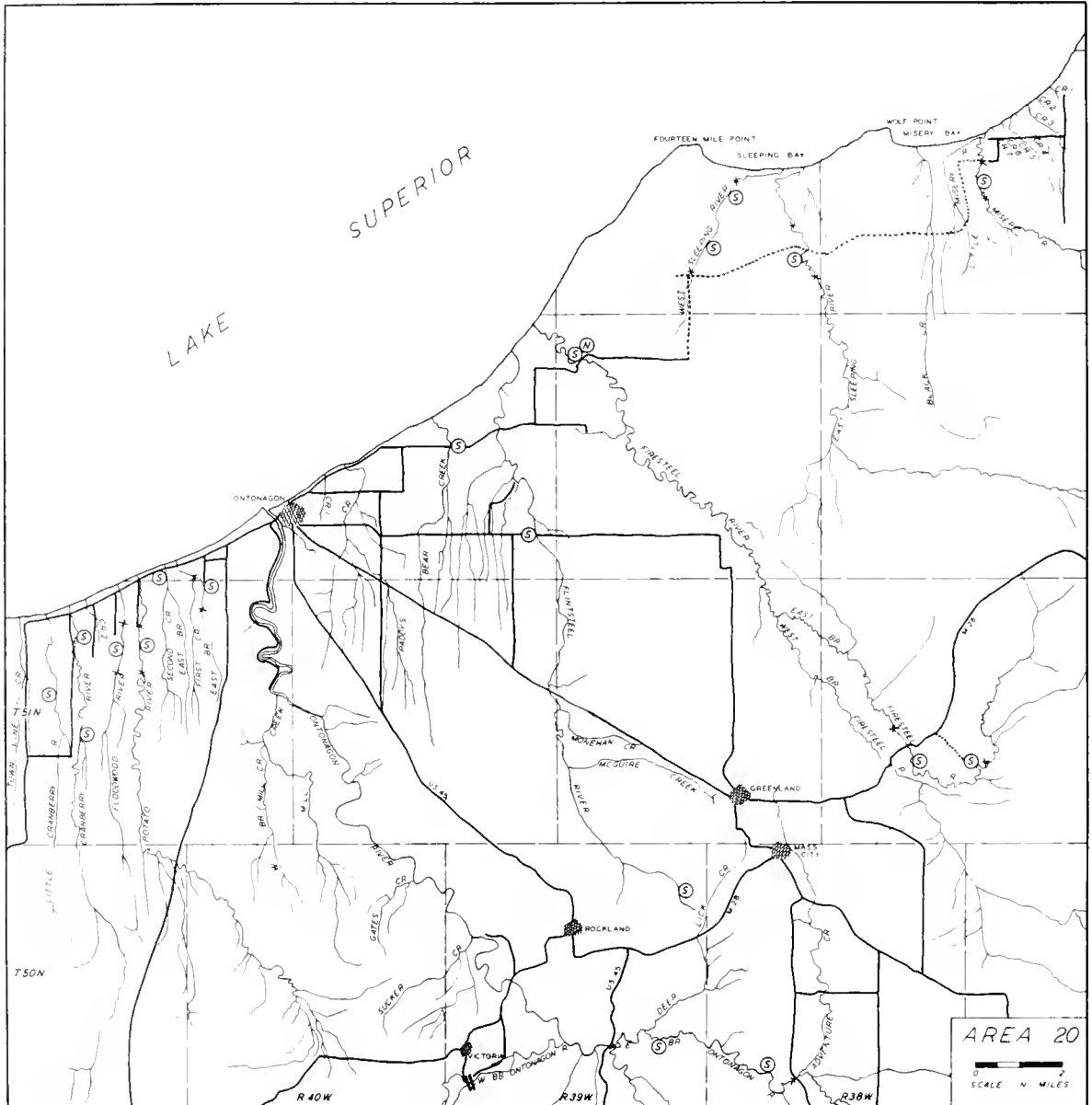


Figure 21.—Area 20.

Description of Area 20 (Fig. 21)

Embraces the northeast portion of Ontonagon County, Mich., and contains at least 13 streams in which sea lampreys may spawn. The status of Paddys Creek and Creek No. 1 just east of Ontonagon, and of Black Creek just east of Wolf Point is unknown at present. Abundant spawning facilities are present in all but three of the streams. Sites for mechanical weirs are present in these three, and the streams themselves are small enough for practical operation of such devices. The 10 streams capable of producing great numbers of sea lampreys are all large, and electrical control devices are recommended for them. Control may be especially difficult in the Ontonagon, Flintsteel, and Firesteel Rivers because of their large size. One lamprey nest was observed in the Firesteel River in 1951. Stream gradients are generally steep, and velocities above the area of "lake level effect" are high. Most of the streams are exceedingly turbid during periods of heavy rain, and changes in water levels are rapid. Low water temperatures and high velocities may limit spawning in some streams. Control operations will be hampered by the inaccessibility of the three or four suitable streams east of Fourteen Mile Point. The entire area is rugged, and lake clay soils are predominant. The forest climax type is largely hemlock-hardwood. Much of the area has been logged recently and is covered with impenetrable slash and second growth.

Table 21.--Potential nest sites, productive potential, recommended control devices, and miscellaneous factors concerning streams in Area 21
(Survey made in 1951)

| Name of stream ^{1/} | County, township line, range, and section no. at mouth | Length of stream in miles ^{2/} | Average width of stream in ft. ^{3/} | Average depth of stream in ft. ^{3/} | Range in stream gradient ^{2/} in ft. ^{3/} | Range in velocity in ft./sec. ^{2/} | Temperature in degrees F. | Date observed ^{3/} | Number of potential nest sites observed ^{3/} | Productive potential ^{3/} | Possible limiting factors | Type of control possible ^{4/} |
|------------------------------|--|---|--|--|---|---|---------------------------|-----------------------------|---|------------------------------------|-------------------------------|--|
| Town Line Creek | Ontonagon, 51-41-1 | 19.0 | 15.0 | 0.6 | Slight-moderate | 0.75 | 54 | 9/5 | 100 ⁺ | Large | Temperature | Electrical |
| Halfway River | Ontonagon, 51-41-1 | 24.0 | 30.0 | 2.0 | Moderate-steep | 1.5 | 59 | 9/6 | 100 ⁺ | Large | Temperature | Electrical |
| Jack Creek | Ontonagon, 51-41-11 | 31.0 | 30.0 | 0.5 | Slight-moderate | 1.5 | 54 | 9/5 | 80 | Large | Temperature | Electrical |
| Pine River | Ontonagon, 51-41-3 | 25.0 | 20.0 | 1.0 | Slight-moderate | Sluggish-1.0 | 55 | 9/5 | 100 ⁺ | Large | Temperature | Electrical |
| Stony Creek | Ontonagon, 51-41-3 | 14.0 | 14.0 | 0.5 | Slight-moderate | Sluggish-1.0 | 54 | 9/4 | 40 | Medium | Temperature, irregular bottom | Mechanical weir & trap |
| Mineral River | Ontonagon, 51-41-7 | 24.0 | 50.0 | 1.0 | Slight-moderate | 1.0-5.0 | 61 | 9/4 | 250 ⁺ | Large | Temperature | Electrical |
| Iron River | Ontonagon, 51-42-12 | 50.0 | 200.0 | --- | Moderate-steep | 1.0-5.0 | --- | --- | 100 ⁺ | Unknown | --- | Electrical |
| Little Iron River | Ontonagon, 51-42-11 | 25.0 | 35.0 | 0.75 | Steep | 1.5 | 52 | 9/4 | 100 ⁺ | Large | Temperature | Electrical |
| Talon River | Ontonagon, 51-42-15 | 14.0 | 40.0 | 1.0 | Slight-steep | Sluggish-2.0 | 51 | 9/3 | 200 ⁺ | Large | Temperature | Electrical |
| Carp River | Ontonagon, 51-44-33 | 30.0 | 35.0 | 0.8 | Moderate-steep | 0.5-2.0 | 53 | 9/9 | 35 | Medium | Temperature, irregular bottom | Barrier dam |

^{1/} List includes only those streams which appear to have a productive potential or for which control devices have been recommended.

^{2/} "Length" is recorded as twice the calculated map distance (the map distance is usually at least doubled by the actual meanders of the stream).

^{3/} Applicable only to the surveyed portion of the stream.

^{4/} From an engineering standpoint, electrical control devices can probably be installed in all streams for which mechanical weirs and traps or barrier dams have been recommended.

^{5/} Stream tributary to another upon which it would be more practical to place a control device.

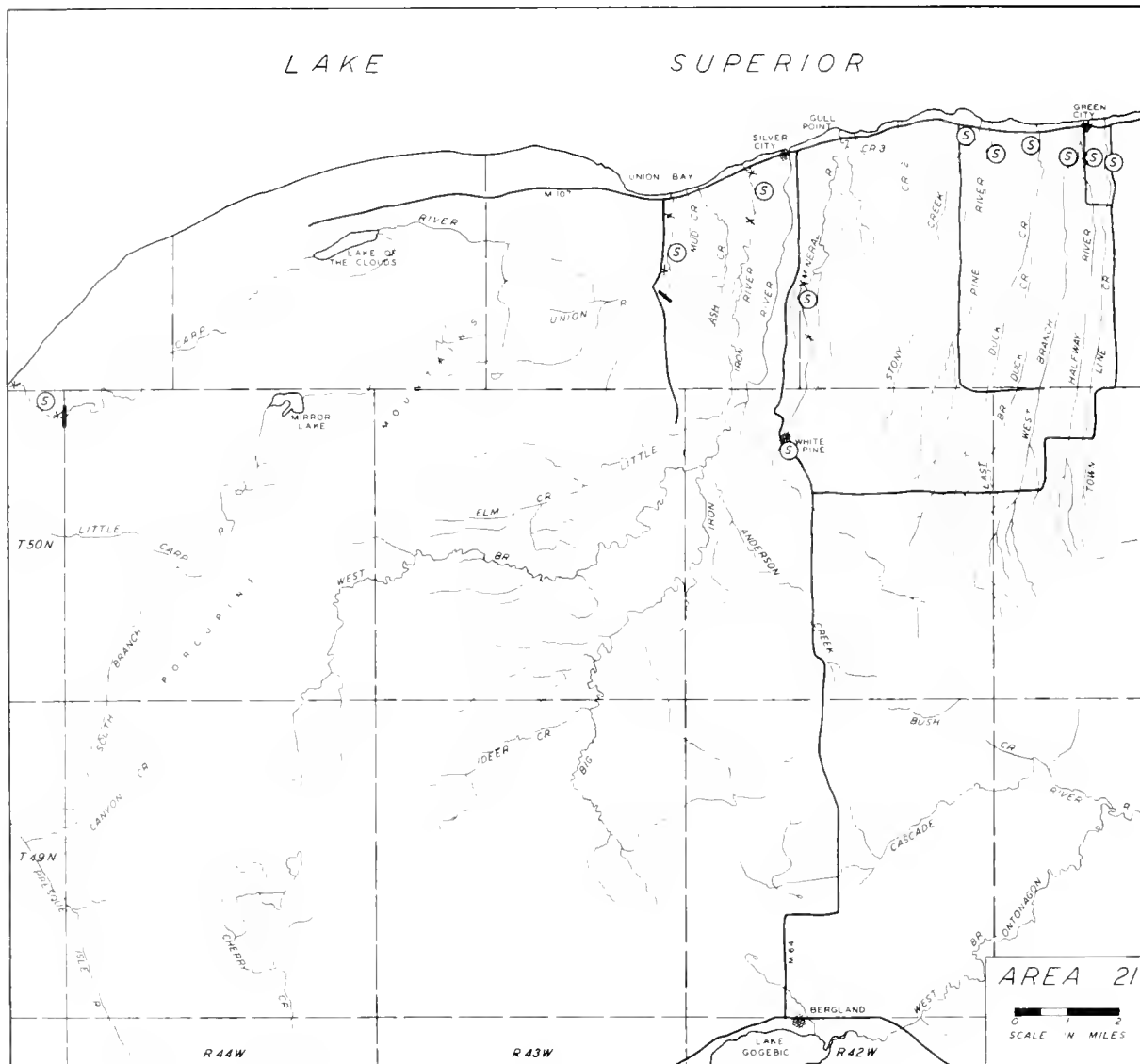


Figure 22.—Area 21.

Description of Area 21 (Fig. 22)

Embraces the northwest portion of Ontonagon County, Mich., and contains at least 9 streams with spawning facilities for sea lampreys. At present, the status of the Iron River and Ash and Mud Creeks is unknown. The shoreline from the Carp River east to Union Bay has not been surveyed; several small streams may be present in this area. Seven streams have a large productive potential while two, Stony Creek and the Carp River, have facilities for fewer nests (30 each). A site for a mechanical weir is present just above the mouth of Stony Creek. The remaining streams (excepting the Carp River in which a barrier can be placed) are too large for control by mechanical means, and electrical devices are recommended. The Carp River is relatively inaccessible. Stream gradients are generally steep above the areas of "lake level effect," and velocities are high. The large water volumes and resulting heavy turbidity may interfere seriously with control operations in the spring and during periods of heavy rain. The surrounding country is rugged. Lake clay soils and a forest climax type of hemlock-hardwood are predominant.

Table 22.--Potential nest sites, productive potential, recommended control devices, and miscellaneous factors concerning streams in Area 22 (Survey made in 1951)

| Name of stream | County, township line, range, and section no. at mouth | Length of stream in miles | Average width of stream in ft. | Average depth of stream in ft. | Range in gradient 3/100 | Range in velocity in ft./sec. | Temperature in degrees F. | Date | Number of potential nest sites observed | Productive potential | Possible limiting factors | Type of control possible |
|---------------------|--|---------------------------|--------------------------------|--------------------------------|-------------------------|-------------------------------|---------------------------|------|---|----------------------|---|--------------------------|
| Creek # 2 | Gegebic, 50-45-2 | 1.0 | 10.0 | 0.2 | Slight-moderate | 1.0 | 56 | 9/9 | 50 | Medium | Temperature | Barrier dam |
| Creek # 3 | Gegebic, 50-45-2 | 1.0 | 6.0 | 0.2 | Slight-moderate | 1.0 | 56 | 9/9 | 50 | Medium | Temperature | Barrier dam |
| Little Carp River | Gegebic, 50-45-2 | 35.0 | 35.0 | 0.8 | Moderate-steep | 0.5-2.0 | 56 | 9/9 | 100 | Large | Temperature | Barrier dam |
| Creek # 4 | Gegebic, 50-45-2 | 1.0 | 2.0 | 0.1 | Steep | 0.75 | 56 | 9/9 | 4 | Small | Temperature, size | Barrier dam |
| Creek # 5 | Gegebic, 50-45-2 | 1.0 | 10.0 | 0.1 | Steep | 0.75 | 55 | 9/9 | 25 | Medium | Temperature, irregular bottom | Barrier dam |
| Finkerton Creek | Gegebic, 50-45-10 | 8.0 | 30.0 | 0.5 | steep | 1.5 | 56 | 9/9 | 80 | Large | Temperature | Barrier dam |
| Kenebeck Creek | Gegebic, 50-45-16 | 5.0 | 15.0 | 0.25 | Moderate-steep | 0.5-1.0 | 56 | 9/10 | 15 | Medium | Temperature, irregular bottom | Barrier dam |
| Creek # 7 | Gegebic, 50-45-16 | 3.0 | 5.0 | 0.25 | Slight | sluggish-0.5 | 56 | 9/10 | 25 | Medium | Temperature | Electrical |
| Creek # 8 | Gegebic, 50-45-16 | 2.0 | 12.0 | 0.25 | Moderate | 1.0 | 58 | 9/10 | 40 | Medium | Temperature | Electrical |
| Tiebel Creek | Gegebic, 50-45-16 | 12.0 | 25.0 | 0.5 | Moderate | 1.0 | 55 | 9/10 | 100 | Large | Temperature | Electrical |
| Speaker Creek | Gegebic, 50-45-16 | 8.0 | 35.0 | 0.5 | Moderate | 1.0 | 55 | 9/10 | 100 | Large | Temperature | Electrical |
| Cardinal Creek | Gegebic, 50-45-20 | 3.0 | 20.0 | 0.25 | Steep | 0.5-1.0 | 53 | 9/8 | 12 | Medium | Temperature, freshets, irregular bottom | Barrier dam |
| Creek # 1 | Gegebic, 50-45-20 | 1.0 | 6.0 | 0.25 | Steep | 0.5-1.0 | 52 | 9/8 | 12 | Medium | Temperature, freshets, irregular bottom | Barrier dam |
| Big Presque Isle R. | Gegebic, 50-45-16 | 50 | 75.0 | 2.0 | Moderate-steep | 2.0-1.0 | 59 | 9/13 | 10 | Medium | Temperature, irregular bottom | Electrical |
| Camp B Creek | Gegebic, 50-45-25 | 5.0 | 20.0 | 0.6 | Steep | 2.0 | 60 | 9/13 | 50 | Medium | Temperature, irregular bottom | Electrical |
| Creek # 1 | Gegebic, 50-45-36 | 1.0 | 6.0 | 0.5 | Moderate-steep | 2.0 | 58 | 9/13 | 30 | Medium | Temperature, irregular bottom | Barrier dam |
| Creek # 2 | Gegebic, 50-45-36 | 1.0 | 3.0 | 0.25 | Moderate-steep | 1.0 | 58 | 9/13 | 30 | Medium | Temperature | Barrier dam |
| Namehigag Creek | Gegebic, 50-45-35 | 5.0 | 8.0 | 0.5 | Moderate-steep | 2.0 | 58 | 9/13 | 80 | Large | Temperature | Barrier dam |
| Silik Creek | Gegebic, 49-45-2 | 4.0 | 10.0 | 0.3 | Steep | 1.0-2.0 | 55 | 9/14 | 50 | Medium | Temperature | Electrical |
| Creek # 3 | Gegebic, 49-45-2 | 7.0 | 7.0 | 0.25 | Moderate-steep | 1.0 | 56 | 9/14 | 25 | Medium | Temperature | Barrier dam |
| Creek # 4 | Gegebic, 49-45-2 | 2.0 | 5.0 | 0.2 | Moderate-steep | 1.0 | 56 | 9/14 | 40 | Medium | Temperature | Barrier dam |
| Manager Creek | Gegebic, 49-45-2 | 4.0 | 6.0 | 0.3 | Steep | 0.5-1.0 | 55 | 9/16 | 35 | Medium | Temperature | Barrier dam |
| Bobulink Creek | Gegebic, 41-45-2 | 4.0 | 6.0 | 0.3 | Moderate-steep | 0.5-1.0 | 53 | 9/15 | 50 | Medium | Temperature | Barrier dam |
| Chickadee Creek | Gegebic, 45-45-3 | 4.0 | 3.0 | 0.25 | Moderate | 1.0 | 53 | 9/15 | 15 | Medium | Temperature | Barrier dam |
| Black River | Gegebic, 49-45-3 | 50 | 125.0 | 6.0 | Moderate | 2.0-3.0 | 57 | 9/17 | 15 | Medium | Temperature | Electrical |
| Falface Creek | Gegebic, 40-45-9 | 2.0 | 6.0 | 0.3 | Steep | 1.0 | 51 | 9/17 | 25 | Medium | Temperature | Barrier dam |

Table 22, continued

| Name of stream | County, township line, range, and section no. | Length of stream in miles | Average width of stream in ft. | Average depth of stream in ft. | Range in gradient 3/ | Range in velocity in ft./sec. 2/ | Temperature in degrees F. | Date | Number of potential nest sites observed 3/ | Productive material | Possible limiting factors | Type of control possible 4/ |
|-----------------------|---|---------------------------|--------------------------------|--------------------------------|----------------------|----------------------------------|---------------------------|------|--|---------------------|-----------------------------------|-----------------------------|
| Creek # 18 | Cogebic, 49-47-20 | 1.0-2.0 | 6.0 | 0.55 | Steep | 1.0 | 54 | 9/20 | 25 | Medium | Temperature, freshets | Barrier dam |
| Creek # 17 | Cogebic, 49-47-20 | 1.0-2.0 | 4.0 | 0.2 | Moderate | 1.0 | 46 | 9/25 | 10 | Medium | Temperature, freshets | Barrier dam |
| Creek # 16 | Cogebic, 49-47-20 | 1.0-2.0 | 5.0 | 0.25 | Moderate-steep | 1.0 | 46 | 9/25 | 25 | Medium | Temperature, freshets | Barrier dam |
| Creek # 15 | Cogebic, 49-47-20 | 1.0 | 6.0 | 0.25 | Steep | 1.0 | 48 | 9/25 | 50 | Medium | Temperature, freshets | Barrier dam |
| Creek # 14 | Cogebic, 49-47-20 | 1.0-2.0 | 2.0 | 0.1 | Moderate | 1.0 | 48 | 9/25 | 1 | Small | Temperature, small size, freshets | Barrier dam |
| Creek # 13 | Cogebic, 49-47-19 | 1.5 | 3.0 | 0.1 | Moderate | 1.0 | 46 | 9/25 | 4 | Small | Temperature, freshets | Barrier dam |
| Creek # 12 | Cogebic, 49-47-19 | 1.0-2.0 | 6.0 | 0.25 | Moderate | 1.0 | 48 | 9/25 | 80 | Large | Temperature, freshets | Barrier dam |
| Creek # 11 | Cogebic, 49-47-19 | 1.0-2.0 | 2.0 | 0.1 | Steep | 1.0 | 48 | 9/25 | 4 | Small | Temperature, small size, freshets | Barrier dam |
| Creek # 10 | Cogebic, 49-47-19 | 1.0 | 6.0 | 0.25 | Moderate | 1.0 | 49 | 9/25 | 12 | Medium | Temperature, freshets | Barrier dam |
| Creek # 9 | Cogebic, 49-47-19 | 1.0-2.0 | 4.0 | 0.25 | Moderate | 1.0 | 48 | 9/25 | 12 | Medium | Temperature, freshets | Barrier dam |
| Creek # 8 | Cogebic, 49-48-25 | 1.0-2.0 | 10.0 | 0.25 | Moderate-steep | 1.0 | 49 | 9/26 | 12 | Medium | Temperature, freshets | Barrier dam |
| Montana Creek | Cogebic, 49-48-25 | 3.0 | 12.0 | 0.3 | Moderate | 1.0 | 48 | 9/26 | 80 | Large | Temperature, freshets | Barrier dam |
| Killdeer Creek | Cogebic, 49-48-26 | 2.5 | 6.0 | 0.3 | Moderate-steep | 1.5 | 49 | 9/26 | 5 | Small | Temperature, freshets | Barrier dam |
| Scalp Creek | Cogebic, 49-48-27 | 3.0 | 12.0 | 0.5 | Moderate-steep | 1.0 | 45 | 9/27 | 7 | Medium | Temperature, freshets | Barrier dam |
| Creek # 4 | Cogebic, 49-48-27 | 1.0-2.0 | 4.0 | 0.3 | Moderate-steep | 1.0 | 45 | 9/27 | 1 | Small | Temperature, freshets | Barrier dam |
| Little Speckled Creek | Cogebic, 49-48-34 | 4.0 | 10.0 | 0.3 | Moderate-steep | 1.0 | 45 | 9/27 | 12 | Medium | Temperature, freshets | Barrier dam |
| Creek # 3 | Cogebic, 49-48-33 | 1.0-2.0 | 2.0 | 0.5 | Moderate | 0.75-1.0 | 45 | 9/26 | 12 | Medium | Temperature, small size, freshets | Barrier dam |
| Creek # 2 | Cogebic, 49-48-33 | 1.0-2.0 | 6.0 | 0.25 | Moderate | 0.75-1.0 | 45 | 9/24 | 50 | Medium | Temperature, freshets | Barrier dam |
| Creek # 1 | Cogebic, 49-48-33 | 1.0-2.0 | 6.0 | 0.2 | Moderate | 0.75-1.0 | 51 | 9/19 | 7 | Medium | Temperature, freshets | Electrical |
| Lewena Creek | Cogebic, 49-48-22 | 3.0 | 6.0 | 0.25 | Moderate | 0.75-1.0 | 52 | 9/19 | 10 | Medium | Temperature, freshets | Electrical |
| Creek # 2 | Cogebic, 49-48-32 | 1.0-2.0 | 10.0 | 0.3 | Moderate | 0.75-1.0 | 53 | 9/19 | 6 | Medium | Temperature | Electrical |
| Uman Creek | Cogebic, 49-48-31 | 6.0 | 4.0 | 0.3 | Moderate-steep | 1.0 | 54 | 9/25 | 25 | Medium | Temperature | Barrier dam |
| Flink Creek | Cogebic, 49-48-11 | 3.0 | 6.0 | 0.3 | Moderate-steep | 1.0 | 56 | 9/25 | 25 | Medium | Temperature | Barrier dam |
| Treasure Creek | Cogebic, 49-49-11 | 4.5 | 10.0 | 0.3 | Moderate-steep | 1.0 | 54 | 9/25 | 12 | Medium | Temperature | Barrier dam |
| Montreal River | Cogebic, 49-49-10 | 50 + | 100.0 | 3.0 | Slight-steep | Sluggish-3.0 | 52 | 9/22 | 5 | Small | Temperature, spawning materials | Electrical |

1/ List includes only those streams which appear to have a productive potential or for which control devices have been recommended.

2/ "Length" is recorded as twice the calculated map distance (the map distance is usually at least doubled by the actual meanders of the stream).

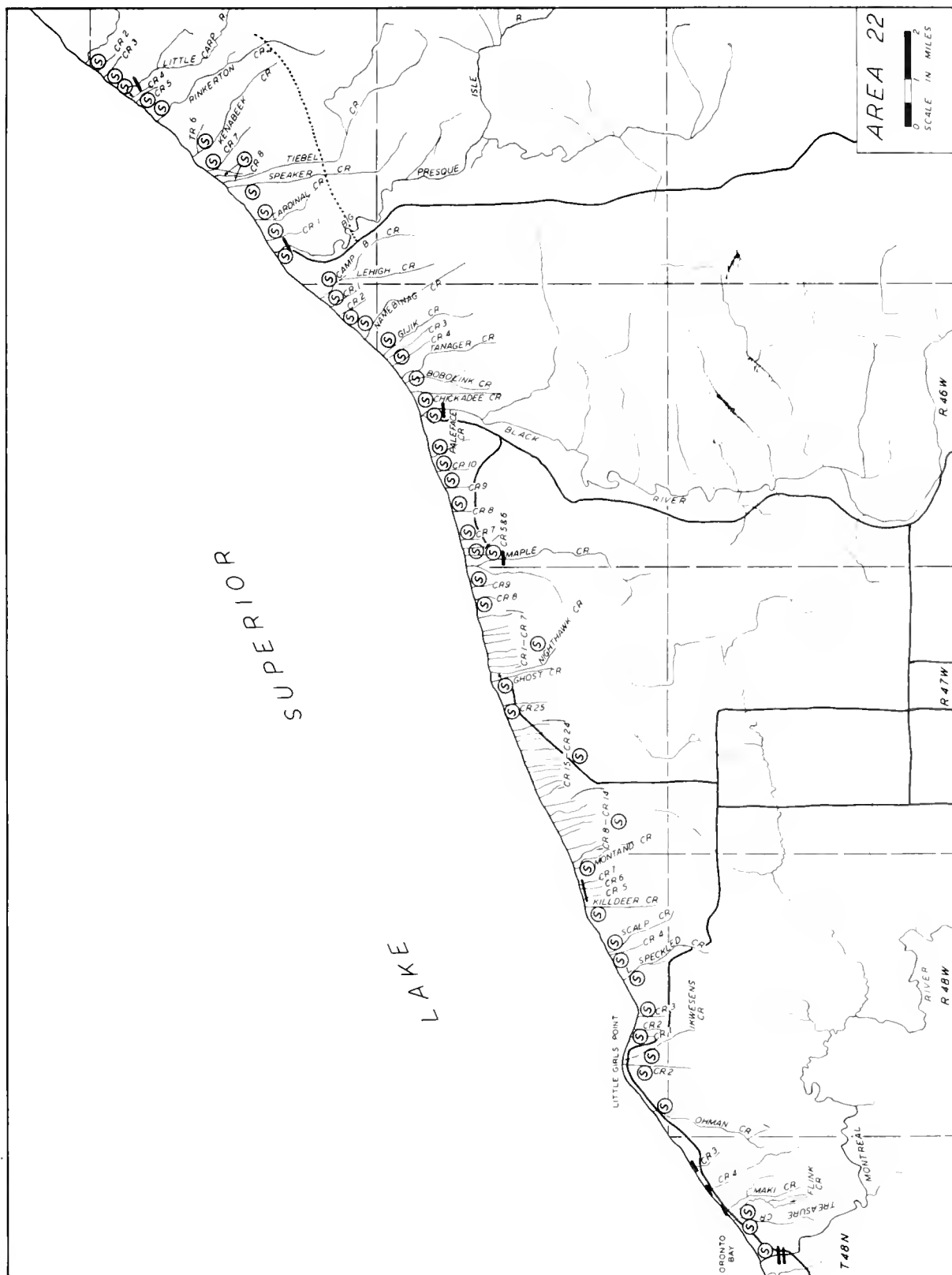
3/ Applicable only to the surveyed portion of the stream.

4/ From an engineering standpoint, electrical control devices can probably be installed in all streams for which mechanical weirs and traps or barrier dams have been recommended.

5/ Stream tributary to another upon which it would be more practical to place a control device.

Table 22, continued

| Name of stream 1/ | County, township line, range, and section no. at mouth | Length of stream in miles 2/ | Average width of stream in ft. 3/ | Average depth of stream in ft. 3/ | Range in gradient 3/ | Range in velocity in ft./sec. 3/ | Temperature in degrees F. | Date | Number of potential nest sites observed 3/ | Productive potential | Possible limiting factors | Type of control possible 4/ |
|-------------------|--|------------------------------|-----------------------------------|-----------------------------------|----------------------|----------------------------------|---------------------------|------|--|----------------------|-------------------------------------|-----------------------------|
| Creek # 10 | Gogebic, 49-46-9 | 1.0 | 6.0 | 0.3 | Steep | 1.0 | 52 | 9/17 | 25 | Medium | Temperature, freshets | Barrier dam |
| Creek # 9 | Gogebic, 49-46-8 | 1.0 | 4.0 | 0.25 | Steep | 1.0 | 52 | 9/17 | 25 | Medium | Temperature, freshets | Barrier dam |
| Creek # 8 | Gogebic, 49-46-8 | 1.0 | 4.0 | 0.2 | Steep | 1.0 | 54 | 9/17 | 25 | Medium | Temperature, freshets | Barrier dam |
| Creek # 7 | Gogebic, 49-46-7 | 1.0 | 2.0 | 0.2 | Steep | 1.0 | 52 | 9/17 | 10 | Medium | Temperature, freshets | Barrier dam |
| Creek # 6 | Gogebic, 49-46-7 | 1.0 | 1.0 | 0.2 | Steep | 1.0 | --- | --- | 3 | Small | small size Temperature, freshets | Barrier dam |
| Creek # 5 | Gogebic, 49-46-7 | 1.0 | 3.0 | 0.2 | Steep | 1.0 | 51 | 9/17 | 4 | Small | small size Temperature, freshets | Barrier dam |
| Maple Creek | | | | | | | | | | | | |
| Creek # 9 | Gogebic, 49-46-7 | 9.0 | 25.0 | 0.5 | Steep | 2.0 | 51 | 9/17 | 30 | Medium | Temperature, freshets | Barrier dam |
| Creek # 8 | Gogebic, 49-47-12 | 1.0-2.0 | 4.0 | 0.25 | Moderate-steep | 1.0 | 52 | 9/18 | 5 | Small | Temperature, freshets | Barrier dam |
| Creek # 7 | Gogebic, 49-47-12 | 1.0-2.0 | 6.0 | 0.25 | Moderate-steep | 1.0 | 52 | 9/18 | 12 | Medium | Temperature, freshets | Barrier dam |
| Creek # 6 | Gogebic, 49-47-13 | 1.0-2.0 | 3.0 | 0.2 | Moderate-steep | 1.0 | 53 | 9/18 | 2 | Small | Temperature, freshets | Barrier dam |
| Creek # 5 | Gogebic, 49-47-14 | 1.0-2.0 | 3.0 | 0.2 | Moderate-steep | 1.0 | 52 | 9/18 | 2 | Small | Temperature, freshets | Barrier dam |
| Creek # 4 | Gogebic, 49-47-14 | 1.0-2.0 | 6.0 | 0.25 | Moderate-steep | 1.0 | 53 | 9/18 | 2 | Small | Temperature, freshets | Barrier dam |
| Creek # 3 | Gogebic, 49-47-14 | 1.0-2.0 | 6.0 | 0.25 | Moderate-steep | 1.0 | 54 | 9/18 | 20 | Medium | Temperature, freshets | Barrier dam |
| Creek # 2 | Gogebic, 49-47-14 | 1.0-2.0 | 6.0 | 0.25 | Moderate-steep | 1.0 | 52 | 9/18 | 4 | Small | Temperature, freshets | Barrier dam |
| Creek # 1 | Gogebic, 49-47-14 | 1.0-2.0 | 3.0 | 0.2 | Moderate-steep | 1.0 | 51 | 9/18 | 15 | Medium | Temperature, freshets | Barrier dam |
| Nighthawk Creek | Gogebic, 49-47-15 | 3.0 | 7.0 | 0.2 | Moderate-steep | 1.0 | 52 | 9/18 | 12 | Medium | Temperature, freshets | Barrier dam |
| Ghost Creek | Gogebic, 49-47-15 | 3.0 | 10.0 | 0.25 | Moderate-steep | 1.0 | 51 | 9/18 | 10 | Medium | Temperature, freshets | Barrier dam |
| Creek # 25 | Gogebic, 49-47-15 | 1.0-2.0 | 4.0 | 0.25 | Moderate | 1.0 | 52 | 9/18 | 12 | Medium | Temperature, freshets | Barrier dam |
| Creek # 24 | Gogebic, 49-47-15 | 1.0-2.0 | 10.0 | 0.25 | Moderate | 1.0 | 56 | 9/20 | 3 | Small | Temperature, freshets | Barrier dam |
| Creek # 23 | Gogebic, 49-47-16 | 1.0-2.0 | 6.0 | 0.25 | Moderate | 1.0 | 57 | 9/20 | 15 | Medium | Temperature, freshets | Barrier dam |
| Creek # 22 | Gogebic, 49-47-16 | 1.0-2.0 | 5.0 | 0.25 | Moderate | 1.0 | 57 | 9/20 | 3 | Small | Temperature, freshets | Barrier dam |
| Creek # 21 | Gogebic, 49-47-16 | 1.0-2.0 | 4.0 | 0.2 | Slight | 1.0 | 57 | 9/20 | 25 | Medium | Temperature, freshets | Barrier dam |
| Creek # 20 | Gogebic, 49-47-20 | 1.0-2.0 | 4.0 | 0.2 | Steep | 1.0 | --- | --- | 25 | Medium | Temperature, freshets | Barrier dam |
| Creek # 19 | Gogebic, 49-47-20 | 1.0-2.0 | 6.0 | 0.25 | Steep | 1.0 | 57 | 9/20 | 25 | Medium | Temperature, freshets | Barrier dam |



Description of Area 22 (Fig. 23)

Embraces the entire coastal area of Gogebic County, Mich., and contains 76 watersheds in which spawning facilities are present. Seven streams, the Little Carp River, Pinkerton, Tiebel, Speaker, and Namebinag Creeks in the eastern portion of the area, and Creek No. 13 and Montana Creek in the western portion each contain facilities for 75 or more nests. Facilities for 6 to 75 nests are present in 53 streams. Sixteen streams contain sites for only 1 to 5 nests. The Big Presque Isle, Black, and Montreal Rivers are very large, and electrical devices will probably provide the only practical means of control. Barriers can be constructed close to the mouths (and below all spawning grounds) of all but 11 of the remaining streams; for the latter, electrical devices are also recommended. Many of the streams are relatively inaccessible. The stream gradients are generally steep, and velocities are high. Heavy rains tend to raise the water levels or a number of streams to the point where they overflow their banks. During such periods, turbidity is high. Low water temperatures and sudden freshets may inhibit spawning in many streams. Freshets, turbidity, and inaccessibility will offer problems in most of the streams when control devices are constructed. The surrounding country is rugged. Lake clays and a hemlock-hardwood climax type are predominant.

Table 23.--Summary of information showing utilization of streams from the Tahquamenon River west to the tip of the Keweenaw Peninsula, 1950, and from the latter point to the Michigan-Wisconsin border, 1951

| Name of stream | County and T-R-S at mouth | Data obtained by survey | | | | Data from other sources | |
|--------------------------|---------------------------|-------------------------|--------------------|-----------|------------|-------------------------|------------------------------|
| | | Number adults found | Number nests found | Date | Larvae dug | Date | Identification of larvae |
| Tahquamenon River | Chippewa, 48-6-14 | 504 | 6/29/50 10 | 6/29/50 | 0 | ... | ... |
| Little Two Hearted River | Luce, 50-9-24 | 0 | ... | ... | 16 1/ | 7/5-7/11/50 | Native lampreys |
| Two Hearted River | Luce, 50-9-27 | 0 | ... | ... | 9 | 7/11-7/25/50 | Native lampreys |
| E. Br. Two Hearted River | Luce, 49-10-1 | 0 | ... | ... | 16 | 7/27-7/28/50 | Native lampreys |
| W. Br. Two Hearted River | Luce, 49-9-6 | 2 | 7/29/50 64 | 7/28-7/28 | 25 2/ | 7/30-7/31/50 | 4 see end 21 Native lampreys |
| N. Br. Two Hearted River | Luce, 48-11-1 | 0 | ... | ... | 6 | 7/28/50 | Native lampreys |
| Sucker River | Alger, 49-13-4 | 0 | ... | ... | 23 | 8/7-8/22 | Native lampreys |
| Baker Creek | Alger, 49-13-4 | 0 | ... | ... | 2 | 8/29/50 | Native lampreys |
| Tributary # 4 | Alger, 48-13-1 | 0 | ... | ... | 2 | 8/18/50 | Native lampreys |
| Creek # 3 | Alger, 49-13-6 | 0 | ... | ... | 3(?) | 8/9/50 | ... |
| Hurricane Creek | Alger, 49-15-3 | 0 | ... | ... | 8 | 8/22/50 | Native lampreys |
| Lowney Creek | Alger, 48-16-17 | 0 | ... | ... | 1 | 9/10/50 | Native lampreys |
| Tributary # 16 | Alger, 48-17-29 | 0 | ... | ... | 2 | 9/14/50 | Native lampreys |
| Mosquito River | Alger, 48-18-25 | 0 | ... | ... | 3 | 9/14/50 | Native lampreys |
| Miner's River | Alger, 47-18-3 | 0 | ... | ... | 11 | 9/8/50 | ... |
| Anna River | Alger, 46-19-2 | 0 | ... | ... | 5 | 9/16/50 | Native lampreys |
| Furnace Creek | Alger, 47-19-29 | 0 | ... | ... | ... | ... | ... |
| Creek # 7 | Alger, 47-19-18 | 0 | ... | ... | 1 | 9/18/50 | Unidentifiable |
| Au Train River (lower) | Alger, 47-20-19 | 0 | ... | ... | 1 | 9/30/50 | Native lamprey |

Upstream migrants (adults) reported seen (resort owners) in springs of 1946 and 1949. (1949 run largest--reached peak in 2nd week of June.)

Dead adults observed (resort owners) on beach at mouth of stream, early summer, 1950.

Five adults and 2 nests observed, July 9, 1950. 5/

Table 23, continued

| Name of stream | County and T-R-S at mouth | Data obtained by survey | | | | Data from other sources | |
|--------------------------|------------------------------|---------------------------|------|--------------------------|---------------|-------------------------|--|
| | | Number adulte found | Date | Number nests found | Larvae dug | Date | Identification of larvae ^{2/} |
| Rock River | Alger, 47-21-15 | 0 | ... | 0 | 0 | ... | Several adults observed (resort owner) below dam at mouth, spring, 1950. |
| Laughing Whitefish River | Alger, 48-25-26 | 0 | ... | 0 | 0 | ... | Ten nests observed, and 4 larvae dug, July 10, 1950. ^{5/} |
| Chocoley River | Marquette, 47-24-6 | 0 | ... | 0 | 0 | ... | Approximately 15 adults, 113 larvae, and approximately 265 nests observed end/or recovered from 8/9 through 8/25/50. ^{5/} |
| Cedar Creek | Marquette, 47-24-9 | 0 | ... | 0 | 0 | ... | One lamprey larva recovered, 9/30-26/50. ^{5/} |
| E. Br. Chocoley River | Marquette, 46-24-14 | 0 | ... | 0 | 0 | ... | Five nests observed 9/14 and 9/15/50. ^{5/} |
| Huron River | Baraga, 52-29-18 | 0 | ... | 0 | 0 | ... | Six larvae dug, September 1, 1950. ^{5/} |
| Revisa River | Baraga, 51-31-4 | 0 | ... | 0 | 0 | ... | Thirteen larvae dug, August 31, 1950. ^{5/} |
| Slate River | Baraga, 51-31-8 | 0 | ... | 0 | 0 | ... | Six probable nests observed, and 5 larvae dug, August 31, 1950. ^{5/} |
| Silver River | Baraga, 51-31-18 | 0 | ... | 0 | 0 | ... | Ten nests observed, and 22 larvae dug, August 31, 1950. ^{5/} |
| Sturgeon River | Houghton, 54-33-33 | 0 | ... | 0 | 5 | 8/29/50 | ... |
| Traverse River | Houghton, 55-31-4 | 0 | ... | 0 | 0 | ... | Five probable nests observed, July 6, 1950. ^{5/} |
| Tobacco River | Keweenaw, 56-30-20 | 0 | ... | 0 | 3 | 8/28/50 | ... |
| Firesteel River | Ontonagon, 52-39-1 | 0 | ... | 1 | 8/27/51 | 0 | ... |

^{1/} One of the 5 taken from the stomach of an 8.5 inch brook trout.

^{2/} A number of larvae were also taken on August 8, 1950 from 10 sea lamprey nests with a square foot bottom sampler. These had been hatched only a short time previous to date of collection, and are assumed to be sea lampreys.

^{3/} Method of identification may be in need of further refinements to assure complete accuracy.

^{4/} Eighty larvae and 15 newly-transformed adults taken with electric shocker, October 6-10, 1950; all identified as native lampreys by Institute for Fisheries Research, Michigan Department of Conservation. The figures 80 and 15 represent the total number of specimens taken from the 3 rivers listed above.

^{5/} Observations by Leo Erickson, Fishery Research Biologist in charge of Marquette, and an office, Fish and Wildlife Service.

LEGEND FOR MAP AREAS 1-22
(SEE FIGURES 2-23)

SPOT LOCATIONS:

ADULT SEA LAMPREYS

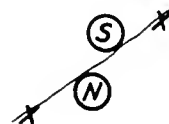
LARVAL SEA LAMPREYS

SEA LAMPREY NESTS

SPAWNING HABITAT

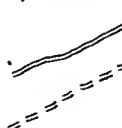
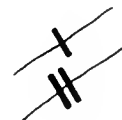


*NESTS OR SPAWNING HABITAT
IN EXTENSIVE AREAS*



NATURAL BARRIER

MAN-MADE BARRIER



GOOD ROAD

POOR ROAD



*BASE MAPS: MICH. DEPARTMENT OF CONSERVATION,
COUNTY MAPS*

Control procedures

Control devices may have to be installed on 194 or more streams between the Tahquamenon River and the Michigan-Wisconsin border. Tentative sites have been located on the majority of the streams, subject to change as warranted by conditions on individual streams and future developments of control devices.

The majority of streams in possible need of control are small (5 to 15 feet in width). A considerable number are in the 15- to 35- foot class. However, at least 57 are large or very large (tables 1-22).

Electrical devices have been recommended for 65 streams which are too large for mechanical weirs or barrier dams or in which good sites for such devices are lacking. Many of these sites are some distance (several miles) from the nearest power lines. Mechanical weirs are recommended for 61 streams, although it is possible that this type of device will be discarded in favor of more practical structures on individual streams (Applegate and Smith, 1951).

Barrier dams are recommended for 68 streams, many of which are difficult of access. Most of these streams are located in Ontonagan and Gogebic Counties. Banks are ravine-like and the substratum at the potential barrier sites is bedrock. Gradients are generally steep; it is believed that mechanical weirs would be difficult or impossible to hold due to the sudden rises in water levels following heavy rains. A number of these barrier dams can be constructed on bedrock outcroppings which are already partial barriers.

Beyond the usual engineering problems accompanying the installation of control devices, the main problem to be faced in the Lake Superior basin is that of relative inaccessibility. Many potential control sites are miles from the nearest roads, and can be reached only by compass course through rugged areas often covered with almost impenetrable slash and second growth.

The control program in Lake Superior logically should be initiated by constructing control devices in those watersheds in which adult sea lampreys, nests, or sea lamprey larvae have already been observed. At the close of the 1951 season these watersheds numbered 15. At the recommended control sites, the main streams of eleven of these watersheds are large, three are of moderate size, and one is small. Details concerning utilization in these particular streams are presented in table 23.

Recommendations for future work

It will be necessary, in the future, to recheck all streams with a productive potential, to determine whether or not they are being used by adult sea lampreys. It is probable that a large number of these streams will never be in need of control measures; spawning may be inhibited by low temperatures, steep gradients, high velocities, relatively small size of a number of streams, and excessive turbidities (lake clay areas of Ontonagon and Gogebic Counties). The more questionable or marginal streams should be rechecked during the regular spawning season to determine accurately their temperatures, velocities, and water levels. The true extent of spawning activity in many streams (notably in Ontonagon and Gogebic Counties) can be determined only by rechecking during the spawning season before most of the nests are destroyed by freshets.

It will be necessary also to carry out further initial surveys of all of the remaining unsurveyed streams flowing into Lake Superior, if the sea lamprey is to be successfully controlled (Wisconsin, Minnesota, Ontario streams, and those on Isle Royale and other islands which have not yet been examined). Many of the unsurveyed areas are relatively inaccessible, and will call for much more highly organized surveys than those carried out to date.

Despite the fact that various types of control structures have been recommended for streams which have a productive potential, it will be necessary to experiment further in order to develop the most practical types. Many Lake Superior streams have characteristics (steep gradients, high velocities, rapid fluctuations in water levels, and extremely heavy turbidity) which, when combined with relative inaccessibility, may present control problems not encountered in previous experimental control operations (Applegate and Smith, 1951).

Literature Cited

Applegate, Vernon C.

1950. Natural history of the sea lamprey (Petromyzon marinus) in Michigan. U.S. Fish and Wildl. Serv., Spec. Sci. Rpt.: Fisheries No. 55, 237 pp.

Applegate, Vernon C., and Bernard R. Smith

1951. Sea lamprey spawning runs in the Great Lakes, 1950. U.S. Fish and Wildl. Serv., Spec. Sci. Rpt.: Fisheries No. 61, 49 pp.

Hile, Ralph

1949. Trends in the lake trout fishery of Lake Huron through 1946. Trans. Am. Fish. Soc., Vol. 76 (1946), pp. 121-147.

Hile, Ralph, Paul H. Eschmeyer, and George F. Lunger

1951. Decline of the lake trout fishery in Lake Michigan. The Fisherman, Vol. 19, No. 1, pp. 5, 10.

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